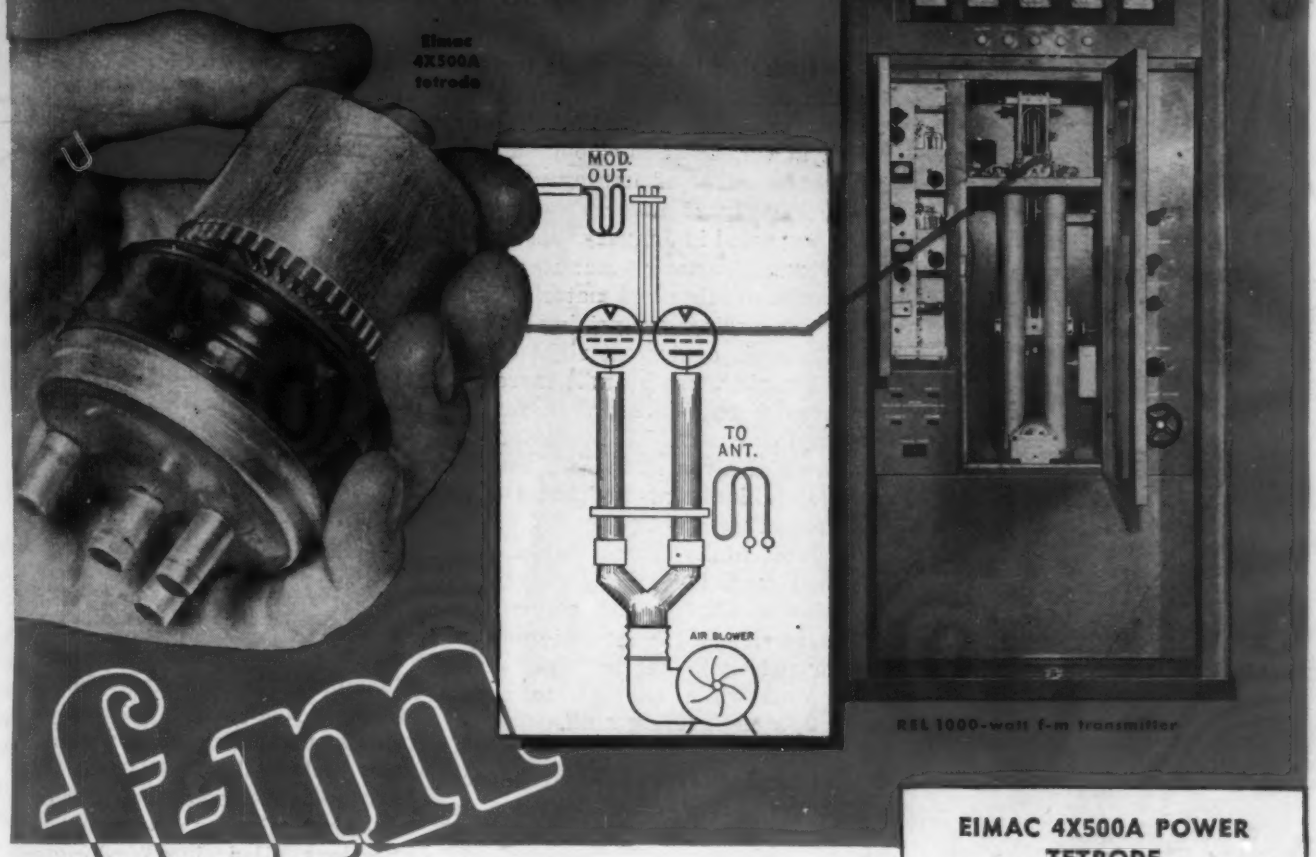
# Chosen for Performance




## f-m

**REL** . . . the pioneer manufacturer of f-m transmitters, has been engineering gear around Eimac Tubes ever since 1939.

One of their latest designs is illustrated above at the right—the 1000-watt unit with Armstrong dual-channel direct-crystal-controlled frequency modulation. For the power amplifier, shown in the center, REL chose a pair of Eimac 4X500A tetrodes because of their remarkable power gain, stability to frequencies above 110 mc, and efficiency. Actually, 70 per cent of the input to the final amplifier is delivered to the load.

In the REL transmitter, less than 20 watts of drive produces the rated kilowatt. In fact, a pair of Eimac 4X500A's can deliver 1750 watts of useful output with only 25 watts of drive; while four tubes in push-pull parallel, taking 50 watts on the grids, put out 3500 watts.

Unwavering stability is achieved in these tubes by combination of exclusive Eimac emission-controlled grids and a concentric-ground-plane ring terminal for the screen grid. Visible in the accompanying illustration, this ring permits finger contact with chassis ground and effective isolation of input and output circuits. Self oscillation is minimized and neutralization, if necessary, is made simple.

### FURTHER POINTS

**GRIDS**...Special treatment suppresses primary emission and controls secondary emission to add efficiency to stability. One hundred per cent useful structure, without interfering supports, and precise alignment between control grid and screen give maximum plate efficiency and low grid current.

**FILAMENT**...Special thoriated tungsten provides high electron emission at low temperature.

### EIMAC 4X500A POWER TETRODE

**Electrical Characteristics**

| | |
|---|---|
| Filament: Thoriated tungsten | |
| Voltage | 5.0 v |
| Current | 13.5 amp |
| Direct Interelectrode Capacitances (Average) | |
| Grid-plate | 0.05 *uuf* |
| Input | 12.8 *uuf* |
| Output | 5.7 *uuf* |

**Maximum Ratings**

| | |
|---|---|
| Plate voltage, d-c | 4000 v |
| Plate current, d-c | 350 ma. |
| Plate dissipation | 500 w |

*Ask for full details on these and other Eimac tubes for f-m, a-m, television, and industrial applications in a comprehensive range of power and frequency capabilities.*

**EITEL-McCULLOUGH, INC.**
**1367E San Mateo Ave., San Bruno, Calif.**
**Export Agents: FRAZAR AND HANSEN**
**301 Clay Street, San Francisco 11, California, U.S.A.**

*Follow the leaders to*

Speakers make the
DIFFERENCE

... and what a
DIFFERENCE!

General Electric Speakers are built to be different—better. For warm, live, pulsating radio and record reproduction, specify speakers by General Electric.

- Better tone quality
- High wattage handling capacity
- No warping of voice coil
- Greater design possibilities
- Overall greater efficiency
- Better controlled air gaps
- Rigidity, strength, durability

Consult General Electric now for your Speaker requirements. Write to: *General Electric Company, Electronics Department, Syracuse 1, N. Y.*

160-7M

GENERAL ELECTRIC

# BUSINESS BRIEFS

By W. W. MacDONALD

**Redesign** is the topside topic of the month. Object: to hold product prices down and quality up, or at very least to embody a sufficient number of improvements to justify higher prices.

Reported in January, the fear is growing among manufacturers that high labor and material costs might result in the pricing of some electronic equipment right out of the market. One hears it expressed everywhere. We heard it, for example, even amid the party atmosphere of a recent Sales Managers Club shindig at the Hotel New Yorker.

Incidentally, there was a very good magician among the entertainers. The thought occurred to us, in view of the current pressure for redesign, that he might make a worthwhile addition to somebody's engineering staff.

**Chassis Makers** note a tendency on the part of their customers to specify elongated and other weird-shaped holes which will accept component parts of different makes. (NEMA and ASA officials say the trend toward standardization of parts is speeding up, much as it did after the first world war.) Also noted is the more frequent inclusion of mounting brackets of various kinds which slightly increase chassis costs but materially reduce subsequent assembly time.

J. H. Scheinman of Minute Man Products came in the other day to suggest that radio engineers consult with their metal stampers early in the design stage so that the latter can suggest possible economies. One of his customers uses one die and movable gages to knock out five, six and seven-tube chassis.

**Distributors** of electronic equipment, and particularly those handling radio receivers, report that they are already encountering serious resistance to higher prices, substantiating manufacturer misgivings. We get this from O. Fred Rost, editor of *Electrical Wholesaling*, who says that the second most disturbing problem faced by the group he knows so well is unbalanced inventories. In this respect distributors and manufacturers appear to be in the same boat.

**Consumer Resistance** to the high prices initially placed on table model radios has now built up to the point where many such sets are going begging for buyers. We predicted trouble on this score last month.

A certain well-known brand is selling in the midwest for (to coin a trick merchandising phrase) cost plus 20 percent loss.

**Mobile Radiophones** are rolling up impressive installation totals in new fields. Taxicab companies alone bought more than $4,000,000 worth in 1946 and FCC applications at present point to a weekly sales potential of $100,000. We have no figures on actual installations, but telephone company applications filed in Washington during the year represented a proposed investment of $2,760,000.

**Component Inventory** reports are now flowing into RMA offices weekly from set manufacturers. Items on which they are short as well as those on which they are long are listed, facilitating the completion of merchandise by swapping among members. Names are held confidential by the Association.

We wired Bond Geddes just be-

**STOCK PRICES**
(Percent decrease, as of Dec. 26, from 1946 high)

| | |
|---|---|
| Bendix | —36% |
| Cornell-Dubilier | —39 |
| Farnsworth | —59 |
| GE | —32 |
| Magnavox | —18 |
| Noblitt-Sparks | —22 |
| Philco | —47 |
| RCA | —51 |
| Sperry | —51 |
| Sylvania | —42 |
| Union Carbide | —26 |
| Westinghouse | —37 |
| Zenith | —54 |
| **Dow-Jones Industrial Average** | —18% |

# INVESTIGATE ...

# Airloop

... THE BUILT-IN LOOP ANTENNA AND CABINET BACK

**one of a battery of presses die stamping AIRLOOPS out of flat sheet copper at 1400 per hour**

**PRODUCING PRECISION MADE AIRLOOPS WHICH PROVIDE BETTER PERFORMANCE AT LOWER COSTS**

*patent #2,401,472*

## AIRLOOPS

Compare AIRLOOPS with conventional loops ... you'll agree no set builder can afford to overlook the significance of the AIRLOOP

- are lower in cost
- increase sensitivity
- have high uniform "Q" over entire band
- have low distributed capacity
- have 27% greater effective loop area
- have electrical and mechanical stability
- are back panel and loop in one
- eliminate individual loop adjustment on assembly line
- effect maximum space utilization
- eliminate haywire
- are air dielectric throughout their entire length.

**FRANKLIN** Airloop **CORPORATION**

43-20 34th ST. LONG ISLAND CITY 1, N. Y.

..tagged for the big jobs!

HEXACON ELECTRIC SOLDERING IRONS

Western Electric

STROMBERG CARLSON

Bendix

MINNEAPOLIS HONEYWELL

Westinghouse

TYPE P-150
This production iron provides a large reserve of heat at the right temperature for sustained production.

Follow the leaders — and you'll use HEXACON! For rugged, heavy duty work or for light, intricate work . . . for continuous production or hard-to-get at Work . . . here's the answer. One reason is "Balanced Heat"—dissipating excessive element-impairing heat — and minimizing element burn-outs and tip replacements. Another, is their light weight, efficiency and dependability.

LITERATURE AVAILABLE—The complete HEXECON line of screw tip and plug tip irons from 40 to 700 watts, and with tip diameters ranging from 1/4" to 1 3/4", is fully illustrated and described. Write today; no obligation.

HEXACON ELECTRIC CO.
130 W. CLAY AVENUE, ROSELLE PARK, N. J.

HEXACON
HIGH-QUALITY, LONG-LASTING SOLDERING IRONS



fore presstime and asked him to list current shortages for us in order of importance. Back came a telegram reading as follows: Principal current shortages are cabinets, tubes, speakers, volume controls and some condensers. Major materials short lead, copper and certain steel plate stampings.

CAA has announced that lack of funds will close 57 aeronautical communication stations and three airport control towers. This dark cloud exhibits some silver lining, however.

There is no indication of cuts in the Authority's radio research and development program. It will ask for $180,000 in the year ending June 1947, as against $80,000 in the previous 12 months. $900,000 is the figure in mind for the year ending June 1948 but our Washington informant thinks this will be cut somewhat by the Budget Bureau before it gets to Congress.

**Radio Receiver Production** should run somewhere between 13 and 18 million sets for 1947, think industry leaders. Around 20 percent of them may include f-m.

**Radio Exports** totalled $27,000,000 in the first eight months of 1946, Brazil taking one fifth and being our best customer. Canada, Mexico, Argentina, China and the Union of South Africa were next in line, in this order.

**Egg And Chicken Question** that puzzled our ancestors had to do with which came first. Modern counterpart involves f-m and television, and until recently there was a lot of speculation as to which one would come first commercially.

Now an answer appears to be emerging from the engineering and economic mists. They seem to be coming along together. Television is being aggressively pushed into the limelight by a few big companies whose production lines are at long last starting to roll. But f-m is likely to make up for its comparative lack of flash in 1947 by virtue of the fact that a larger number of manufacturers will produce and promote it.

**F-M Applications** filed with the FCC between January 1939 and October 1946 break down as follows: 70.8 percent from owners of a-m stations (some with newspaper interests), 12.3 from non a-m newspaper interests, and the remaining 16.9 from people having neither a-m station nor newspaper interests.

**Television Receiver Production** should hit between 320,000 and 360,000 in 1947, thinks RMA's R. C. Cosgrove. (RCA is set up to produce 160,000 sets at an average list of about $400, according to George Beers. $600,000 worth of testing facilities have already been set up. )

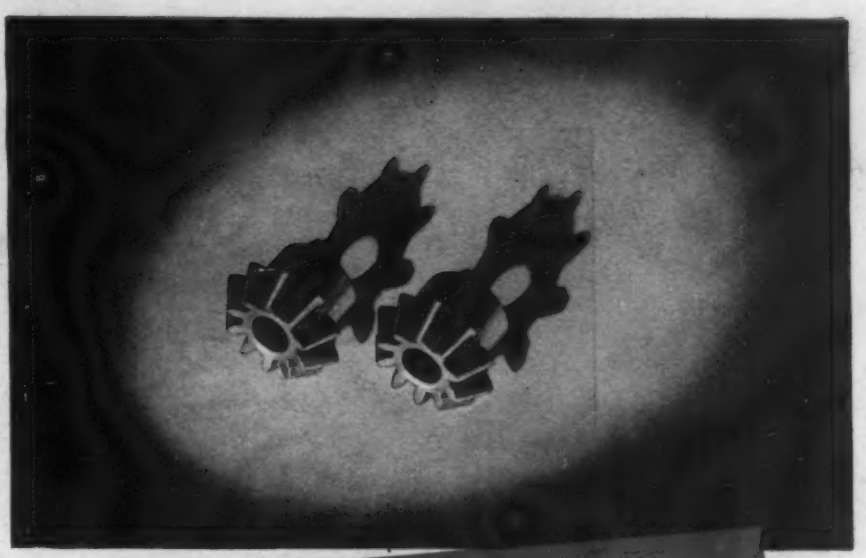
**Speaking Of Color,** a rooter for black-and-white television remarked the other day at an off-the-record meeting that the word red is frequently coupled with the word herring.

**Receiving Tube Sales** for 1946 totalled between 193 and 195 million, says M. F. Balcom, chairman of RMA's tube division, who thinks production and demand will be substantially in balance by spring. Current production is running about 40 percent better than in 1941.

**Broadcast Networks** total 38, the number of affiliated stations ranging from 384 in the case of Mutual down to three. American has 238, Mississippi Valley 78, Don Lee 39, Yankee 23, Quaker 18, Texas State 16, Wolverine 14, Northwest 12 and Arkansas 10.

**Employable Veterans** available through the New York offices of the Veterans' Administration alone total several hundred at the present time. L. S. Krull of the Rehabilitation Training and Education Subdivision (252 7th Avenue) dug out the following facts about men anxious to secure technical jobs in the electronics field for us:

Average age 24, two years high-school, attended some civilian radio school. About 1 percent have some pre-war radio experience, 20 percent were radio technicians in the services, 2 percent have had some practical radio experience since.

Need FINE PITCH BEVEL GEARS?

Experience and skill are heavy factors in correctly producing fine pitch straight bevel gears. Teeth with proper bearing — minimum runout — accuracy of form and bevel — all of these involve special experience which Beaver Gear Engineers have gained in developing straight bevels up to 64D.P., and finer in some cases. Highly specialized production methods and inspection equipment insure gears made to exact specifications.

For assistance with your problems on straight bevel gears, write or phone us for recommendations. No obligation of course.

**Spurs, Helicals, Straight Bevels, Sprockets, Racks, Worms, Worm Gears, Thread Grinding Complete Gear Trains**

***Write Today for this FREE BULLETIN***

Describes Beaver Gears facilities and methods, also includes table of gear tooth parts.

Beaver Gear Works Inc.

1021 PARMELE STREET, ROCKFORD, ILLINOIS

# What? Hospital Gauze Not Good Enough?

## Not For This MALLORY Capacitor!

Gauze, such as is used in making "fabricated plate" for Mallory FP capacitors, must be of the highest purity obtainable. Believe it or not, the best gauze used in hospitals falls far short of the purity required for Mallory fabricated anode plate.

To be sure, hospital gauze is sterile. But it contains chlorides and other adulterants that play havoc with capacitor performance. The chloride content of the gauze used by Mallory *is less than one-half of one part per million.* Extra watchfulness and constant co-operation between plant and supplier are required to maintain such standards.

It is because of Mallory's vigilance in small details that dependability and Mallory capacitors are synonymous.

**Everything you want to know about Mallory electrolytic capacitors—types, sizes, electrical characteristics—even data on test measurements and mounting hardware. Write today for a free copy.**

P. R. MALLORY & CO. Inc.

**MALLORY CAPACITORS**

**(ELECTROLYTIC, OIL and WAX)**

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

# CROSS TALK

▶**WANTED . . .** The third of a billion dollars spent on research by OSRD during the war, most of it in the field of electronics, failed to uncover the answers to certain problems posed by the Air Forces. Major J. G. P. Callahan, speaking at the Carnegie Institute of Technology, listed them as follows:

1. The measurement of and indication of true airspeed of aircraft from 0 to 1,000 miles per hour and of missiles up to 4,000 miles per hour.
2. The measurement and indication of true height of aircraft above the sea level datum up to 80,000 feet and of missiles up to 80 miles.
3. A method of determination of the vertical in maneuvering aircraft.
4. A celestial ground-position indicator for use in aircraft during day and night with an accuracy of ±3 miles.
5. Methods of polar navigation.
6. Automatic indication of load balance in aircraft.
7. A simple remotely-indicating system for engine rpm, pressure and temperature in aircraft.
8. A system of measurement of fuel and oil quantity, especially accurate when the quantity is small.

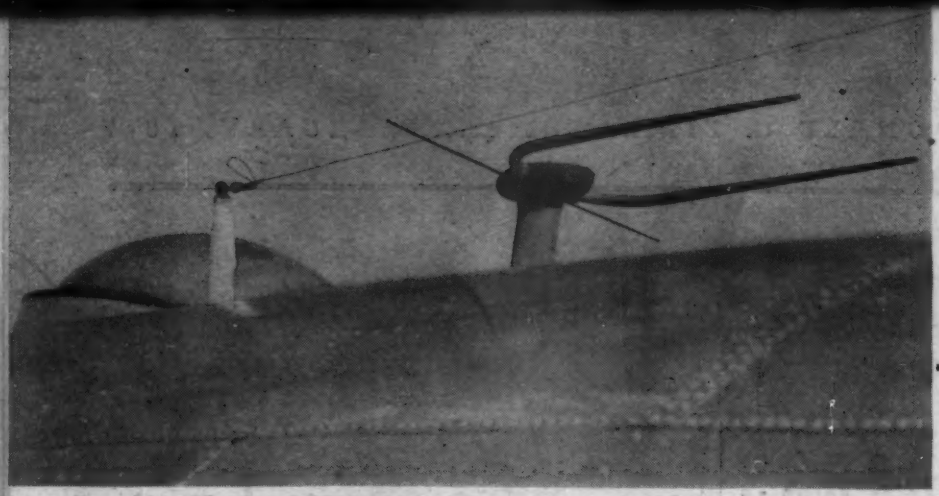
These needs are still unsatisfied. The solutions have immediate application to commercial, as well as military, aviation. Electronic methods of navigation and instrumentation are indicated. Any answers?

▶**ULTRASUPER . . .** Our editors, concerned with consistent style, are plagued by the words "ultrasonic" and "supersonic". They are used interchangeably and apply with equal vagueness to velocities (higher than that of sound) and frequencies (above the audible range). Inquiry reveals that the preferred usage, among those working with both quantities, is supersonic for velocities and ultrasonic for frequencies. This is an arbitrary choice, since the words themselves give no clue (super and ultra mean above and beyond, respectively). So, with us at least, it's supersonic for aircraft and missiles, and ultrasonic for vibration.

We try also, and recommend the practice to engineering writers, to avoid the adjectives above or below when referring to wavelengths and frequencies. Higher or lower for frequencies. Longer or shorter for wavelengths. Class dismissed.

▶**COLUMBIUM . . .** The unassisted reception of WBAL's radio programs by a piece of very cold columbium nitride, reported by Johns Hopkins University, is the first authenticated version of a long line of reports, starting with the lad who persisted in receiving WOR on the filling of a tooth. The nitride incident is covered in Electron Art (p 142, this issue). The Johns Hopkins people state no theory of how it works, but we picked one up from an old friend who has worked with columbium for, lo, these many years: The nitride reaches the superconductive state at a certain temperature (about 14 degrees above absolute zero) and its resistance suddenly drops. Moreover if its temperature varies in the vicinity of the critical temperature, its resistance varies accordingly. The sensitivity is enormous and the material can go in and out of superconductivity at a rate of hundreds of kilocycles per second. When nearby WBAL produced an r-f field in the nitride, each half of each r-f cycle heated the material, and the resistance changed proportionately to the depth of modulation. A high-gain audio amplifier and loudspeaker attached to said nitride did the rest. We can't vouch for this, but it sounds good. The man with the filling had no theory at all. He was just sore.

Watch this superconductivity business. Superconductive microwave cavities, made of lead immersed in liquid helium, can display circuit Q's far above those of room-temperature circuits or crystals. Theory points to Q's in the millions. And the ice-box technique is not so difficult as it might appear.



Antenna installation on aircraft for utilizing instrument landing system recommended by PICAO. Glide-path signal is picked up by dipole, while streamlined nondirectional ram's-horn antenna receives localizer signals

# International Plan for Air Navigation

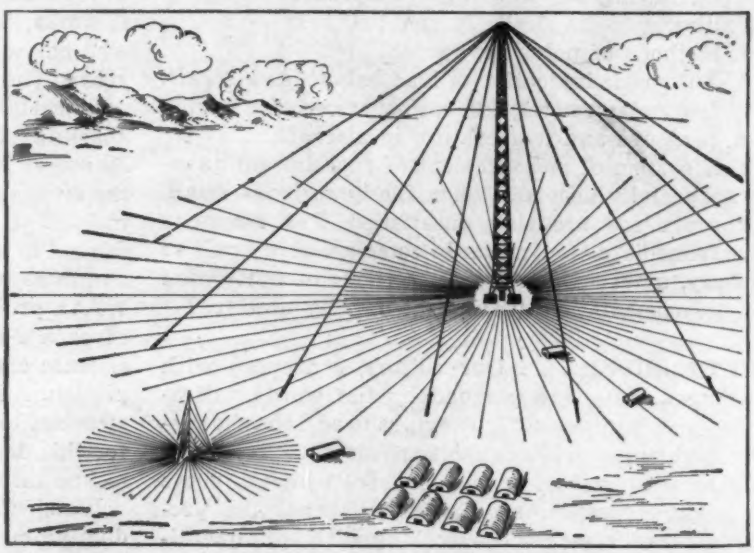
**PICAO group picks CAA instrument landing system for international airports. Radar distance-measuring beacons and vhf omnidirectional radio ranges were recommended for short-range navigation, with low-frequency loran as an interim long-range navigation aid**

THE Provisional International Civil Aviation Organization (PICAO) has recently been considering existing and proposed systems of radio navigation and communication for world-wide standardization[1]. Delegates from 29 of the 46 member nations attended meetings of the Special Radio Technical Division of the PICAO Air Navigation Committee, held at Montreal between October 30th and November 23rd, and made recommendations to the council which, if adopted, will become mandatory for the member nations.

### Operating Specifications

Before any recommendations could be made, it was necessary to agree on a set of quantitative operational requirements for the various aspects of air navigation and traffic control. Once this had been achieved, recommendations on existing systems for immediate standardization were soon made. Later, attention was turned to systems still in the experimental stage and a number of techniques were recommended for further development. This work now gives the development engineer a most valuable background on which to plan his program.

The most pressing problem in airline operation today is the landing of aircraft under conditions of poor visibility, at a rate equal to that at which the air traffic control organization can feed them into the approach zone. It was, therefore, recommended that at all interna-



Layout of low-frequency loran station recommended by PICAO as international aid to long-range air navigation. Radiator tower is 625 feet high, with top-loading umbrella of twelve 325-foot radials for efficient radiation at 180 kc. In foreground is small antenna for receiving synchronizing pulses from master station, along with Quonset huts for housing equipment and stores

**By D. H. PAIN**
*Staff Engineer*
*RCA International Division*
*Radio Corporation of America*
*New York, N. Y.*

**Experimental CAA installation of distance-measuring-equipment antenna on belly of DC-3. Though 1,000 mc was used for this radar interrogator-responder beacon in U. S. development work, PICAO has requested a 40-mc band between 200 and 300 mc to make propagation characteristics correspond to those of other recommended radio aids**

tional airports a standard instrument landing system (ILS) should be installed as soon as possible and certainly not later than January 1st, 1951.

#### Instrument Landing

The system chosen for standardization includes a localizer, a glide path, and marker beacons. Basically it is the CAA system[2], but eventually will incorporate a new type of localizer developed by the CAA in which 90 and 150-cps modulation is no longer used. Instead, 30-cps sideband patterns are radiated in such a manner that the phase of the resultant received 30-cps modulation reverses as the on-course line is crossed. Then by radiating a nondirectional reference phase signal as 30-cps frequency modulation on an ultrasonic subcarrier, it is possible to derive course indication in the aircraft by phase-comparison techniques.

A principal advantage of this system is that it enables a single aircraft receiver and indicator to be used for both instrument landing and short-range navigation, as described later. For this reason it was recommended that a changeover to phase-comparison localizer equipment should begin in 1951.

In many countries U. S. AAF surplus type SCS51 instrument landing equipment, although not complying completely with PICAO standards, will probably be kept in operation as a temporary expedient.

In order to give the pilot a continuous indication of distance from the touchdown point, it was recommended that by 1952 the markers should be supplemented by a short-range beacon to give this information to aircraft equipped with radar distance-measuring equipment (DME). This makes use of the well-known interrogator-responder technique, and the various ground transponder beacons are to be identified by coding the reply pulses.

#### Short-Distance Navigation

In the short-range navigation area where high accuracy is required for precise traffic control, the group decided to recommend a vhf omnidirectional radio range[3], used in combination with a DME beacon on the same site. This system presents position information in the form of azimuth and range, and is commonly known as an R-$\theta$ system. In the particular case of Europe, where routes are not necessarily along well-defined airways, a regional conference will be held to consider whether the R-$\theta$ facilities to be installed at terminals of long-distance routes should be supplemented by the British-sponsored Gee system. Chains of Gee stations installed during the war already cover most of western Europe with a lattice of hyperbolic position lines. These are provided in the same manner as in the standard loran system[4], but transmissions are made in the vhf band.

The principle of the vhf omnirange depends on the production of a heart-shaped polar diagram which is effectively made to rotate in space at 1,800 rpm. This is achieved by feeding a five-element quincunx antenna array through a rotating capacitance goniometer. The received signal then varies in amplitude at 30 cps and the phase of this signal depends on the azimuth bearing of the receiver. In order to determine this variable phase, another signal which carries a fixed 30-cps reference phase as f-m on an ultrasonic subcarrier is radiated by the central nondirectional antenna only. By making these two 30-cps signals coincide in phase in

**Experimental search radar installation at CAA control tower in Indianapolis. PICAO encourages further development to solve such problems as obtaining a sufficiently bright ppi presentation for reliable observation in a brightly illuminated control tower**

a direction due North of the station, the azimuth of a receiver lying in any other direction becomes equal to the phase difference measured in degrees.

#### Long-Distance Navigation

In considering the long-range navigation problem it was immediately appreciated that standard loran was already providing sufficiently important coverage over certain vital areas to warrant additional installations as the demand arose, but that full transoceanic coverage was not feasible with the limited ground wave propagation characteristics of the present 2-mc frequency band. By using a frequency of 180 kc it is hoped to provide the required reliable range of 1,500 miles with the l-f loran system, though at some sacrifice in accuracy resulting from the necessarily longer pulses (300 microseconds). Since the l-f signals can be received on the standard loran receiver with the aid of a simple frequency adaptor, this system was considered as showing the most promise of satisfactorily complementing the existing facilities.

Accordingly it was proposed to set up a PICAO commission to be responsible for trial installations in certain difficult coverage areas, on a schedule including the North Atlantic in 1949 followed by S. E. Asia, Africa, Australasia, Pacific, and South Atlantic by 1952.

Realizing that such proposals could probably never satisfy all the requirements, particularly in respect to accuracy (10 miles at maximum range), further development was encouraged on other systems such as Consol, and satisfaction was expressed over the intention of the CAA to complete its trials of the l-f omnidirectional radio range.

Whether for long or short-range navigation, an immediate requirement was seen for a system providing for flight along any desired track which would not necessarily be coincident with the guides naturally laid down by either an R-$\theta$ or a hyperbolic system. For this requirement encouragement was given to the development of computers which would derive information from the basic radio system and guide the aircraft either automatically or by providing the pilot with the right kind of information. Another suggestion particularly applicable to long-range navigation was for a dead reckoning computer which would periodically correct its indications by reference to the radio system.

Although installations of the standardized ILS are to proceed immediately it was realized that the system has serious limitations. Principal among these is the inability to provide for simultaneous approaches on multiple parallel runways; in such installations the areas of permissible error in azimuth associated with each runway will overlap at some distance from the airport. To overcome this trouble the development of a system was suggested, which would provide hyperbolic approach tracks diverging with increasing distance from the runway. Such a system would offer little improvement over the standard ILS in respect to course errors due to reflections, and for this purpose some form of narrow-beam microwave system was recommended. It was considered, however, that real promise of striking improvement lay only along some more original approach to the problem.

#### Future Possibilities

With improvements such as these a new bottleneck was expected to develop in the control of traffic on the surface of the airport, particularly in the clearance of runways. A promising solution to this problem was thought to lie in the development of high-resolution surveillance radar, possibly supplemented by wheel-actuated detectors and induction-leader cables.

Surveillance radar was also discussed for use in air traffic control. The desirability of presenting the same type of traffic picture to both the ground controller and pilot was stressed. Precision-approach radar of the type used in GCA (ground-controlled approach) was advocated to monitor and possibly supple-

**Table I—Frequency Allocations Desired by PICAO**

Requests for the following frequency bands, required now or likely to be needed in the future for air-navigation systems, may be filed by PICAO member states with the International Telecommunications Union·

| | |
|---|---|
| VHF Omnirange | 112–118 mc |
| Distance-Measuring Equipment | 40-mc band between 200 and 300 mc |
| ILS Localizers | 108–112 mc |
| ILS Glide Path | 328.6–335.4 mc |
| ILS Markers | 75 mc |
| Microwave ILS | 5,000–5,250 mc |
| GCA Precision Radar | 8,500–10,000 mc (9,300–9,320 reserved for transponder beacons) |
| Surveillance Radar | 2,700–3,000 mc (3,246–3,266 reserved for transponder beacons) |
| Standard Loran | 1,800–2,000 mc |
| L-F Loran | 20-kc band near 180 kc |

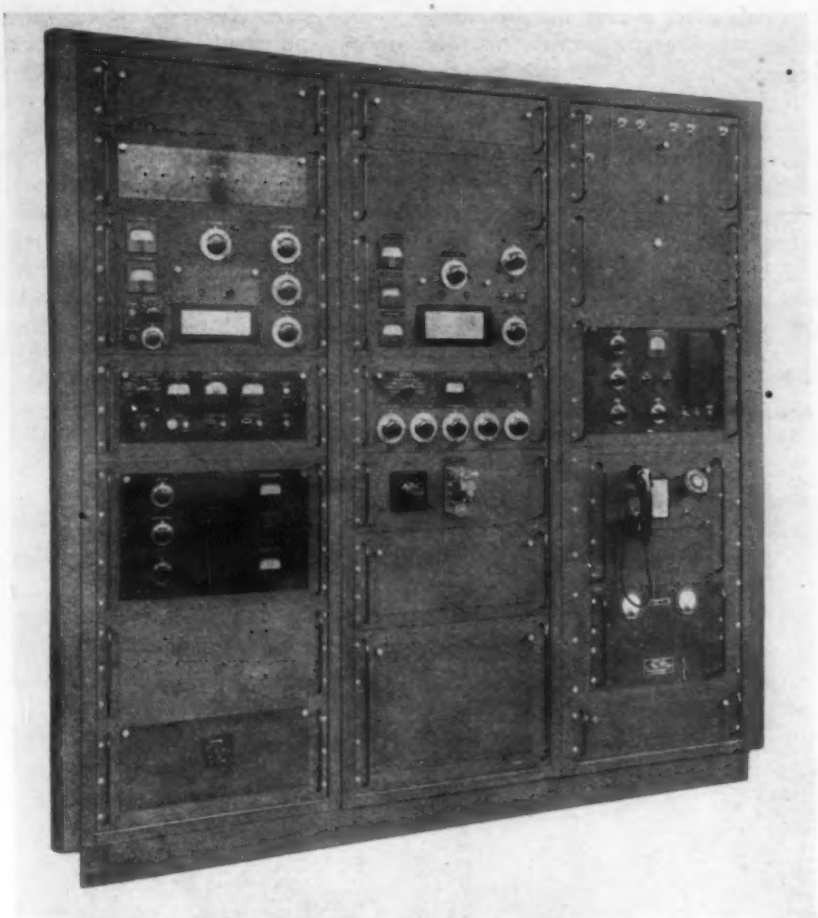
ment instrument landing system facilities. The other half of the air traffic control problem was seen to lie in improving the efficiency of the short-distance ground-air communication facilities. For this purpose some form of visual message presentation was advocated as a solution which would also help solve the language difficulties associated with international operation.

For long-distance communication two-way radiotelephony with aircraft was seen as a requirement to replace the present c-w code transmissions, but it was realized that this could not be done by the mere expedient of increasing the transmitter power, owing to the limit set by corona discharge from the antenna at high altitude. To overcome this difficulty it was suggested that the possibilities of narrow-band frequency modulation and single-sideband transmission should be investigated.

The recent tremendous increase in the number and importance of long-range flights has also given rise to a new technique known as pressure pattern flight. This technique makes use of an accurate knowledge of the weather in order to take full advantage of the upper atmosphere winds, and usually involves flying along an isobaric track. In order to do this it must be possible to detect in flight any change in the atmospheric pressure pattern which may occur after takeoff. It was foreseen that this might ultimately be accomplished by the periodic transmission of weather maps by radio facsimile, but for the immediate future the continued use of the present method was envisaged. Here a change in pressure is detected by comparing the reading of the barometeric altimeter with that of a radio altimeter.

The radio altimeter also received consideration in connection with the special difficulties encountered in the siting of an instrument landing system for water landings of flying boats. The low-altitude f-m altimeter used throughout the war as the AN/APN-1 functions ideally over the plane surface of water and, in conjunction with radar distance-measuring equipment, could provide the basis for an entirely synthetic glide path generated in the aircraft by a computing device.

**Dual-range indicator of experimental airborne radar distance-measuring equipment, to be used with instrument landing system and with vhf omnidirectional radio range to indicate distance from beacons**



**Basic vhf navigation equipment. Interchanging a single panel of this ground station unit will make it conform to PICAO standards for the vhf omnidirectional radio range or either the equisignal or phase-comparison type of localizer for the instrument landing system**

Throughout the discussions in Montreal, it was obvious that great benefit was derived by the interchange of information and opinions which was possible at such an international gathering. Before dispersing, therefore, the Radio Technical Division recommended that a permanent group within PICAO should be set up to observe, encourage, and guide the future development of radio aids to navigation of all types, as well as to disseminate their findings among all the member nations. Provisions were also made for initiating requests now for frequency allocations likely to be needed in the near future, as summarized in Table I.

### References

(1) U. S. Demonstrates Radio Aids to Air Navigation, ELECTRONICS, p 280, Dec. 1946.

(2) Caporale, Peter, Civil Aeronautics Administration Instrument Landing System, Part I—p 116, Feb. 1945; Part II—p 128, March 1945.

(3) Luck, D. G. C., An Omnidirectional Radio Range System, RCA Review, Part I—July 1941; Part II—Jan. 1942; Part III—March 1946.

(4) The Loran System—Part I, ELECTRONICS, p 94, Nov. 1945; Loran Receiver-Indicator, ELECTRONICS, p 110, Dec. 1945; Loran Transmitting Stations, p 109, March 1946.

**Using subminiature tubes and comparably small circuit components, one can build electronic equipment small enough to be comfortably carried in a suit pocket. Design data, types of components that are available, and possible applications are presented**

ode and two CK507AX's. One section of the 3A5 was connected as a grid-modulated oscillator for transmission. For reception the circuit comprised a separate squelch oscillator and a super-regenerative detector, two stages of audio amplification, and an insert-type magnetic receiver. The antenna for operation between 250 and 300 mc was a dipole at the end of a two-wire line which plugged into the top of the case. The set had a range of a mile, a battery life under continuous operation of 12 hours, and a weight of 2.5 lb. A radio built along these lines for operation in the Citizens' Band would fill some of the previously suggested applications nicely.

A boon to reporters and others who must record verbatim what is said will be a portable wire recorder now in development. Wire and tape recording can be done under conditions of vibration for which disc recording is not feasible, and without any other adjustment than maintaining the proper volume level to the recording head. In the particular developmental unit referred to, the wire, run at as slow a rate as is consistent with intelligible recording of speech, is driven by a 2-volt permanent-magnet motor. A spool carries wire for recording 30 minutes. The unit is powered by a rechargeable 2-volt battery having 2-hours' life, and a 45-volt B-battery having upwards of 100-hours' life. The electronic circuit uses four subminiature tubes, types CK503AX, CK505AX, and CK510-AX. The unit has a frequency response within plus or minus 5 db from 100 to 3,000 cps.

An inch-long Geiger counter tube of such small diameter that it can be inserted in one's veins to meter passage of radioactive tracers whose activity is insufficient to produce measurable radiation outside the body has been developed at the University of California. Such a small tube, combined with other midget components, makes possible a wearable radiation counter that could be carried concealed on one's person to locate illicit manufacture of fissionable materials.

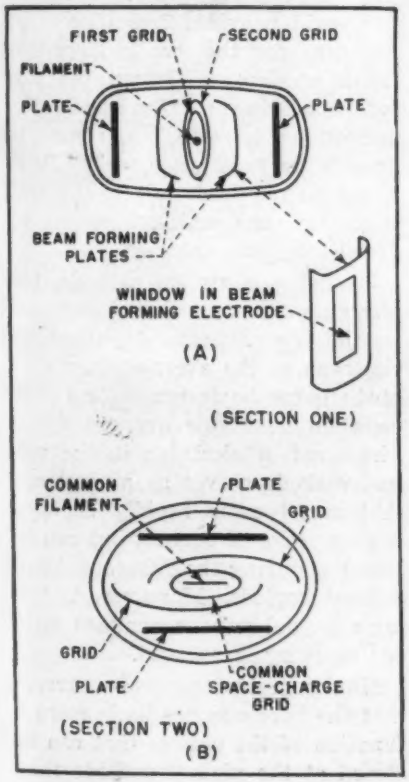
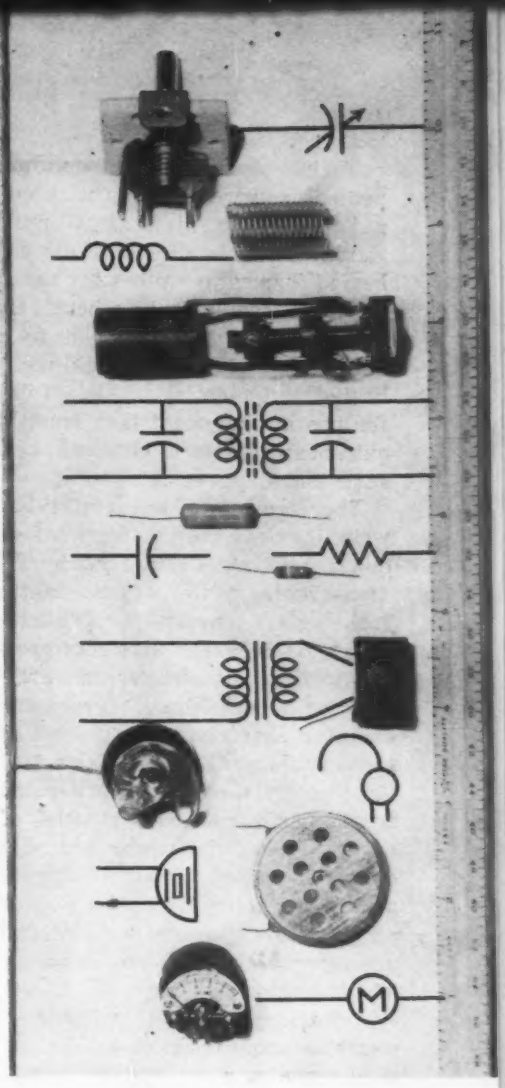



**FIG. 1—(A) Cross section of beamed-power tube shows use of windows to form secondary emission suppressing beams. (B) Cross section of space-charge tetrode shows use of virtual cathode to reduce filament heating power**



**Small components illustrate the reasons why equipment can be built to small dimensions**

Other applications of the extremely small units that can be built using these techniques include improved radiosonde sets carried aloft by balloons for weather observation, telemetering equipment in rockets projected into the ionosphere for high-altitude studies, geophysical sounders more readily lowered into oil wells a mile below the earth's surface, portable radar-type aids for the blind (now undergoing tests), and airborne telemetering and control equipment. Much impetus was given to these developments by the radio proximity fuze.

### Tubes

There are commercially available in subminiature size most of the major types of electronic tubes, such as the sharp-cutoff radio-frequency pentode, the triode-heptode frequency converter, a diode-

# MIDGET ELECTRONIC EQUIPMENT

MIDGET electronic equipment, small enough to be carried comfortably in one's pocket, is no longer uncommon. Wearable broadcast receivers are in production. That some personalized receivers will be nothing more than novelties is to be expected. However, they do have useful applications. At ball parks, for example, announcements are frequently more intelligible over the radio than over the public address system.

A wearable radio would be a definite contribution to such isolated individuals as the forest ranger, rancher, surveying crew, and lumberman. Compact, low power drain, light weight electronic equipment, operating in the Citizens' Band, could put outdoor people in immediate communication with their base camps.

The FCC has a one-tube field intensity meter, called a Sniffer, that is small enough to be held in the palm of one's hand. From time to time people illicitly using radio transmitters and receivers concealed about their persons, or built into unobtrusive camera-sized boxes, have been caught. Most frequent use of such sets has been to relay horse-race results to bookies or gamblers for placing late bets after a race was over but before the results were generally known.

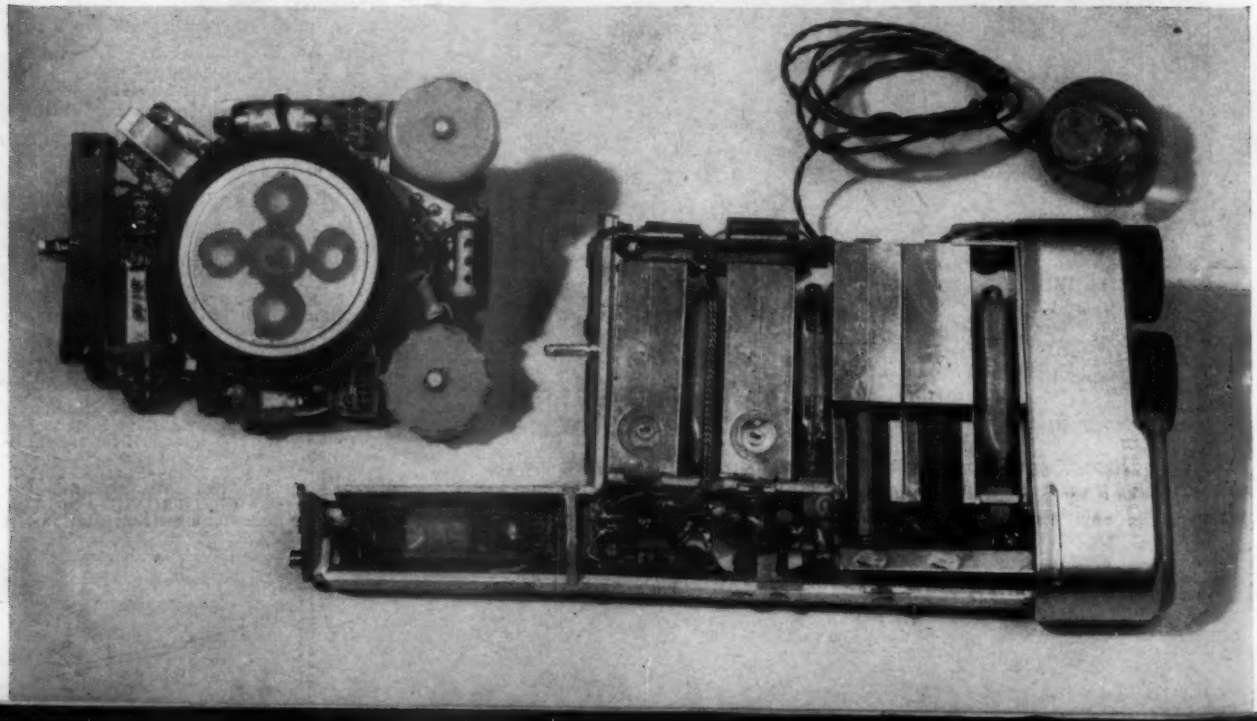
### Applications

Hearing aids are the most familiar application of electronic equipment built to wearable dimensions. Subminiature tubes and midget components have been developed over the years for use in hearing aids. Much progress has been made in improving the performance of hearing aids and in reducing their size.

That the conflicting requirements of compactness and reliable performance can be simultaneously satisfied is illustrated by the use of wearable radios during the war. Using parts and techniques developed previously for hearing aids, pocket communication equipment was designed for advance troops who, if they carried bulky radio equipment, were singled out as key men and made the first target of snipers.

During their activities in Germany, OSS men used a wearable transceiver for communication with airplanes which flew overhead on pre-arranged schedules to receive reports and transmit instructions. The set consisted of a 3A5 miniature high-frequency duotri-

**In the upper left is a hearing aid assembly with the battery clip detached. The microphone is in the center with the tubes and components disposed where space permits. In the foreground is a five-tube superheterodyne pocket broadcast a-m receiver. The batteries go in the space to the left of the chassis. Inductive tuning is used**



thus lengthening the life of the A-battery. The independence of the two triode sections, provided no cathode impedance is added to the external circuit, is sufficient to enable them to be operated in cascade to give an overall gain of over 40 db.

### Sockets

Filamentary tubes are available either with long leads for wiring directly to the circuit or with short leads for insertion into sockets. Designers of industrial equipment often prefer to solder tubes into the circuits to be sure of rigid, corrosion-resistant connections. They also prefer to make the equipment semipermanent. (One manufacturer is planning a series of premium subminiature tubes that will have long life for use in semipermanent equipment.) In cases where space is extremely limited, it may be desirable to omit the socket. For very high-frequency circuits it may also be desirable to omit the socket both to eliminate a possible source of r-f loss and to shorten the leads to reduce shunt capacitance and series inductance.

Designers of communication equipment, accustomed to using tube sockets, ordinarily prefer them. The fact that in flat-press tubes the leads are along a straight line means that they can be started into the socket at an angle by bending all the leads, pushed home, and then stood erect among the compactly placed parts of the equipment. Thus little headroom need be left over the tubes. Parts can be located immediately adjacent to the tube, the tube being removed as it was put in—by being tilted out from its normal position to where one can readily grasp it before it is pulled out. These tubes are coated with Aquadag, the coating being connected to a normally grounded lead, so that an electrostatic tube shield is unnecessary.

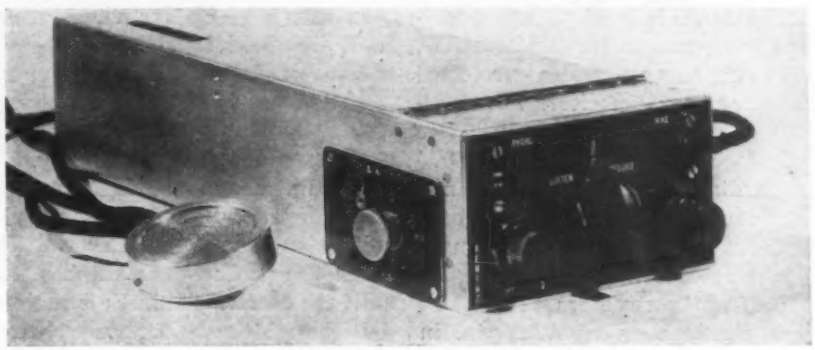
There are two types of sockets now available: a completely assembled socket, and a group of individual clips that, when mounted on an insulating chassis, form a socket. The first type has the advantage of pre-assembly, because it is only necessary to fasten it into the chassis. The latter, available experimentally, has the advantage of compactness, because it comprises only the essentials of the socket, the metal clips; the plastic or impregnated fiber chassis forms the base.

One method of mounting the assembled socket is illustrated in Fig. 2. A hole is cut in the chassis to accommodate the socket. The flange around the top of the socket keeps it from passing through the hole; a retaining clip, slipped on from the bottom, holds the socket in the hole. Another method is to put the socket in a hole in a metal chassis and punch the chassis on either side of the socket hard enough to cold flow metal into recesses in the sides of the socket. For mounting the tube in the most advantageous position, it may be necessary to locate the socket on an angle strap. During tests for socket leakage on this assembled type, resistance between pins after immersion for 48 hours in an atmosphere of 90 percent relative humidity and 50 C measured 2,000 meg. These particular plastic sockets are useful up to 60 mc; polystyrene sockets are available

**Table 1—Characteristics of Typical Filmentary Subminiature Tubes**

| Tube Number | Structure & Application | Filament V | Filament MA | Plate Voltage | Transconductance in μmhos | Circuit Amplification | Power Output in Milliwatts[a] |
|---|---|---|---|---|---|---|---|
| 2E31<br>2E32[b] | (Sharp-cutoff r-f pentode ampl'fier) | 1.25 | 50 | 45 | 500[c] | — | — |
| 2E35<br>2E36[b] | (Output pentode) | 1.25 | 30 | 45 | 500[c] | — | .6 |
| 2E41<br>2E42[b] | (Diode-pentode detector, amplifier) | 1.25 | 30 | 45 | 375[c] | 20 | — |
| 2G21<br>2G22[b] | (Triode-heptode frequency converter) | 1.25 | 50 | 45 | 60[d] | — | — |
| CK502AX | (Output pentode) | 1.25 | 30 | 45 | 550[e] | — | 6 |
| CH503AX | (Output pentode) | 1.25 | 30 | 45 | 550[e] | — | 9.5 |
| CK505AX | (Pentode amplifier) | 0.625 | 30 | 30 | 175[e] | 35 | — |
| CK506AX | (Output pentode) | 1.25 | 50 | 45 | 500[e] | — | 25 |
| CK507AX | (Output pentode) | 1.25 | 45 | 45 | 575[e] | — | 11 |
| CK510AX | (Double space-charge tetrode amplifier) | 0.625 | 50 | 45 | 65[e] | 150[f]<br>16 | —<br>— |
| CK515BX | (Triode amplifier) | 0.625 | 30 | 45 | 160[e] | — | — |
| CK521AX | (Beamed output) | 1.25 | 50 | 22.5 | 400[e] | — | 6[g] |

[a] Measured at ten percent total distortion
[b] Lower number indicates leads are long enough to solder into circuit; upper number indicates leads are clipped for insertion into socket
[c] Measured at zero plate and screen resistance
[d] Conversion transconductance
[e] Per section
[f] Two sections in cascade
[g] Internal plate resistance 220,000 ohms; into 20,000 ohms



(D) Pocket wire recorder

pentode detector-amplifier, and pentode power amplifiers with output powers as high as 25 milliwatts. There is a series of directly heated filamentary tubes for use in wearable equipment where the power drain must be held to a minimum, and a series of indirectly heated unipotential cathode tubes for use in equipment that must be extremely compact but can consume usual powers.

The filamentary series of tubes, weighing less than a tenth of an ounce, are housed in flat T-2 by T-3 (two-eighths by three-eighths inch) glass envelopes no longer than 1.57 in. The filaments operate at 1.25 volts or less and draw between 30 and 50 ma. Types and essential characteristics of some of these tubes are listed in Table 1.

Although these tubes are rated for a maximum plate potential of only 45 volts, the power pentodes deliver sufficient power to operate an air-conduction earphone. More power can be obtained where necessary from push-pull or parallel operation of several tubes. Power triodes are not desirable in wearable equipment because of their relatively low power sensitivity. Low internal resistance of the output amplifier, necessary to damp some of the magnetic earphones, can be more readily obtained by voltage negative feedback in the pentodes than by using triodes.

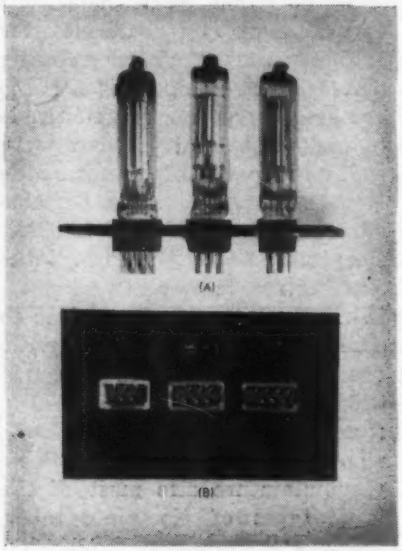


FIG. 2—Tube socket is held in chassis hole by retaining clip, thus eliminating space otherwise required for bolts

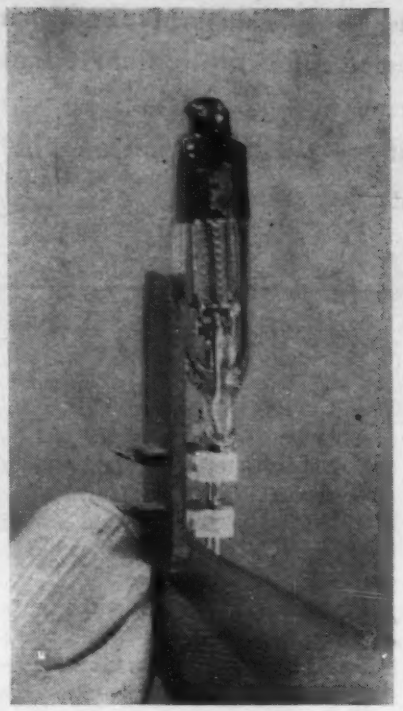


FIG. 3—Experimental subminiature tube socket consists of individual clips for each lead, mounted in nonconducting chassis. A small piece of plastic is used to illustrate the mounting method

In designing the output stage of electronic equipment, one begins with the required output and works backward. The output power required to operate an insert type earphone ranges from one to 100 mw, depending in part on the efficiency of the receiver itself and partly on the acuity of the individual ear. The medium value for hard-of-hearing persons can be taken as 20 mw. Allowing for a 20-percent power loss in the output transformer, an average value for miniature transformers, one obtains, as the required output power from the tube, 25 mw. With 4.5 volts peak on its grid, and no negative feedback, a CK506AX output pentode will deliver this power. In the case of equipment designed for persons with normal hearing, negative feedback could be used to decrease distortion, and still leave sufficient output.

The most recent development in subminiature tubes is the CK521AX beamed power tube. It approaches the beam tetrode in characteristics, yet can be made in smaller size. The first and second grids are not aligned; the sacrifice in performance being more than made up in simplification of assembly. A thin metal window shown in Fig. 1A concentrates the electrons to the plate into a dense beam that suppresses secondary emission. To get optimum spacing between the second grid and the window and between the window and the anode, the plane of the electrodes is perpendicular to the long axis of the envelope rather than parallel to it as in other subminiature tubes. A grid bias of minus three volts is recommended with 22.5 volts on plate and screen.

Power to heat the filaments of these tubes is most critical. Although there are available several efficient A-batteries, they are exhausted before the B-batteries in most equipment. The CK510AX illustrates one of the techniques developed to fully utilize filament heating power. The tube consists of two space-charge tetrodes using a common filament. The first grid, extending through both sections of the tube as shown in Fig. 1B is used as a positive space-charge grid to produce a virtual cathode. The electron cloud formed at the first grid provides a reservoir of electrons for the two independent triode sections. Without the virtual space-charge cathode, the filament would have to be designed to provide the peak space current that might be required, despite the fact that this peak emission might be drawn only momentarily.

By using a virtual cathode, the filament can contribute electrons to the virtual cathode cloud of electrons at the average tube current and can be designed for a peak emission near this average value. The cloud of electrons in the virtual cathode serves as a reservoir that can become rapidly depleted during peaks of current but can be restored during the subsequent low current periods. Moreover, by using a virtual cathode, common cathode coupling is reduced.

Maximum instantaneous current that the tube can handle is more a function of the charge that can be stored at the virtual cathode than of the physical electron emission of the hot filament. By taking advantage of this storage in a virtual cathode, the filament can be designed for lower heating power,

whether operated continuously or intermittently, has nearly constant output voltage and substantially constant internal resistance at audio frequencies throughout its life. A substantially flat voltage characteristic is maintained throughout life up to rated current drain (50 ma max), thus efficiency is maintained during life. The voltage drops quickly at the end of the cell's useful life. Of particular interest in wearable equipment is the fact that, volume for volume, the cell has three to four times the ampere-hour capacity of a conventional zinc-graphite dry battery. The corrosion-resistant steel case, acting as positive terminal, does not enter into electrolytic action of the cell.

Carbon-zinc cells are made in a variety of sizes for compact assembly, with the A- and B-batteries scaled to comparable dimensions, as shown in Fig. 6. The familiar layer-built B-batteries, which have duplex electrodes (zinc on one side, carbon on the other) to conserve space, are made in 15, 22.5, 30, 45, and other voltage sizes. The efficiency of energy conversion from chemical to electrical is higher in these flat cells than in comparable zinc-graphite cells of other shapes, and for the same external size they contain a larger volume of depolarizing mixture than cylindrical dry cells, and have higher zinc utilization. These batteries can readily be broken open between cells to obtain any intermediate voltage for use in experimental portable equipment. The stack must be restrapped to keep the cells pressing tightly on one another if the internal resistance of the battery is to be kept low. Because the inert plastic case does not enter into chemical action with the paste, there is no danger of corrosive chemicals eating through the container and damaging adjacent parts.

Research into the action of the carbon-zinc cells indicates that their efficiency of energy conversion can be increased. These cells are still undergoing development.

Battery equipment is usually designed to such tolerances that it will work until the battery terminal voltage has fallen to two-thirds its initial value. For example, an A-battery is expected to remain in service until its initial 1.4 volts has fallen to about 0.9 volt. However, in the B-battery circuit, the increase in internal resistance of the battery may result in interstage coupling before the terminal voltage has fallen to this low value. This coupling through the battery impedance can be reduced by external decoupling filters, or usually by a large bypass capacitor across the B-battery. The bypass capacitor should have very little shunt leakage, or else be disconnected when the circuit is not in use. In one very small hearing aid model recently marketed, opposing feedback of the signal appearing across the battery is made to the last two stages to reduce the battery coupling and thereby obtain longer B-battery life.

### Methods of Providing Grid Bias

Although many subminiature tubes are designed for zero grid bias, others require a small negative bias. Because of the inevitable decrease in plate supply potential, some provision must be made for the grid bias to decrease correspondingly, if the tube is to continue operating effectively during the entire battery life.

Self bias is the simple and obvious method of obtaining the necessary simultaneous decrease in grid bias with loss in B-voltage. The self bias resistor will, of course, cause considerable loss in tube amplification if unbypassed, but will improve the linearity of the effective transfer characteristic, thereby decreasing harmonic and intermodulation distortion.

In pentode output stages, the increase in the tube's internal impedance caused by this current feedback may be objectionable in certain applications. To prevent this cathode degeneration, a large bypass capacitor is required, with added space requirements. That the bypass capacitor will occupy considerable space will be recognized from its capacitance. In a typical circuit the CK507AX with a plate and screen supply of 45 volts requires a grid bias of minus two volts and conducts an average space current of 1.2 ma. (Although the required grid bias is small, the low plate current necessitates a large cathode resistor.) The self biasing resistor must be 1,670 ohms. The bypass capacitor that, in shunt with this resistance, gives a time constant of 0.01 sec (period of a 100 cps signal) is 60$\mu$f. In addition, the A-battery will have to be insulated from ground, which is usually preferable to wasting heater power in the cathode resistor (even though the cathode resistor would then be smaller, but requiring a much larger bypass capacitor) which would be necessary if the A-battery were grounded.

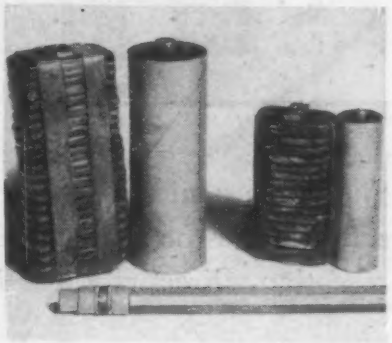


FIG. 6—Batteries for wearable equipment are available in a variety of types and sizes. Shown here are two pairs of A- and B-Batteries with their paper covers removed; both pairs give the same voltage

One means of counteracting the degeneration introduced by an unbypassed cathode resistor is to provide positive feedback across the cathode resistor from the plate circuits.

If voltage amplification can be sacrificed, voltage feedback can be used in the output stage to decrease the effective internal impedance of the tube. The components of such a circuit usually require less total volume than the cathode bypass capacitor, although the A-battery drain may be higher because of an added tube. However, the combined effects of these feedbacks will be complex and can lead to instabilities. Whatever the solution, it is usually a compromise between minimum bulk and minimum battery drain.

Material for this article has been obtained from more sources than can reasonably be listed here. To those who generously supplied information, greatful appreciation is extended.—F. R.

experimentally for higher frequencies.

The clip type of socket offers a method of mounting tubes on an insulated chassis, using minimum space. The socket shown in Fig. 3 is built of heat-tempered beryllium copper that has been formed into individual lead clips and relieved of stresses so as to eliminate spring-back and distortion. The clips are inserted into the insulating chassis, two banks of clips being used to obtain wide spacing. Tube leads pass through an aligning hole in the top of each clip and between the folded flaps below, where they are held by spring grip.

Good practice in mounting tubes

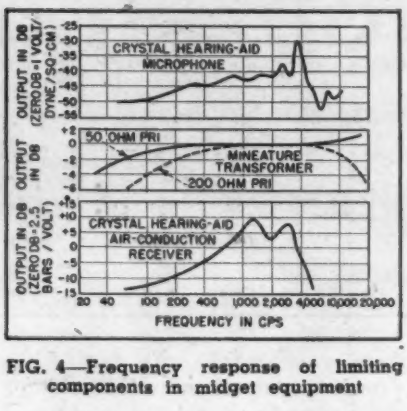

OUTPUT IN DB (ZERO DB = 1 VOLT/ DYNE/SQ-CM)
CRYSTAL HEARING-AID MICROPHONE
OUTPUT IN DB
50 OHM PRI
MINEATURE TRANSFORMER
200 OHM PRI
OUTPUT IN DB (ZERO DB = 2.5 BARS / VOLT)
CRYSTAL HEARING-AID AIR-CONDUCTION RECEIVER
FREQUENCY IN CPS

**FIG. 4—Frequency response of limiting components in midget equipment**

is to provide holding cushions of rubber at their tops. To connect wires to the sockets in the small space, welding is being used in some instances. Welding's advantage over soldering is ease in reaching the connection with reduced damage from hot irons and spilled solder or flux, however a welded connection is difficult to service.

### Components and Construction

Frequency responses of typical components are shown in Fig. 4. Considering their small size, their performance is good. Small capacitors and resistors are also available. Wax-impregnated resin-protected tubular paper capacitors are available in capacitances from 0.002 to 0.1 $\mu$f, the largest ones being 0.376 in. in diameter and 1.125 in. long; the smaller capacitors are only 0.625 in. long and correspondingly thinner.

Half-watt resistors from 10 ohms to 22 meg are 0.125 in. in diameter and 0.375 in. long; they are rated at 70 C in anticipation of the higher ambient temperatures that may be reached in the compact closed assemblies of wearable equipment. Large powers are usually not available in midget equipment, so high wattage components need not be used.

Several techniques of metalizing insulated mounts to form the electrical connections of an electronic unit have been proposed as a means of both simplifying the assembly of small units and conserving space. Metal leads can be printed onto ceramics by a screen process or deposited either on the surface or in grooves by spraying through a mask; foil can be stamped onto plastic bases or baked on.

It has been found desirable because of variations in circuit parameters, particularly of thermionic tubes, common to all sizes of components, to construct calibrated pre-assemblies. Components are matched to give the required circuit characteristic and to balance one another's drifts in each unit. The pre-assemblies are then interchangeable. One such standardized multivibrator is shown in Fig. 5. In it subminiature tubes and selected resistors have been connected and mounted on a plug for connection into the complete equipment.

Tubes consisting of up to three separate tubes, either triodes, tetrodes, or pentodes in various combinations, mounted on one socket, have been manufactured in Europe. In some models the tubes are connected through resistance-capacitance networks built into the assembly.

Overall size of midget electronic equipment intended to be carried in one's pocket is the major factor determining its utility. Measurements on size of pockets in numerous men's suits, including vests, indicate that the most frequently encountered pocket size is from 2.5 to 3.0 inches wide. It was similarly found that the optimum depth of a wearable unit is between 5 and 6 in., long enough not to be out of reach at the bottom of a pocket, yet not so long as to project awkwardly from the pocket. The thinner the unit the better. Thinness is limited by the thickest component that must fit into the assembly, in this case, the B-battery. The thinnest usable B-battery is 0.56 in. thick.

### Batteries

Filament heating power requirements are most severe, as was pointed out in describing tubes designed for wearable equipment. The fact that filamentary cathode tubes can be quickly heated to operating temperature and so need not be kept hot during standby is a major factor in their favor for all portable equipment. In addition, high powers for which large, indirectly heated cathodes are necessary are not encountered in wearable equipment. Most stages of electronic circuits operate at low power levels, thus high plate power capacity is unnecessary. The problem is to supply the power to heat the filaments, small though that power is.

Recently a new dry cell having a high ampere-hour capacity was experimentally developed. An internal potential of about 1.34 volts is produced between mercuric oxide and zinc electrodes. Because of its negligible polarization, this cell delivers the same ampere-hours

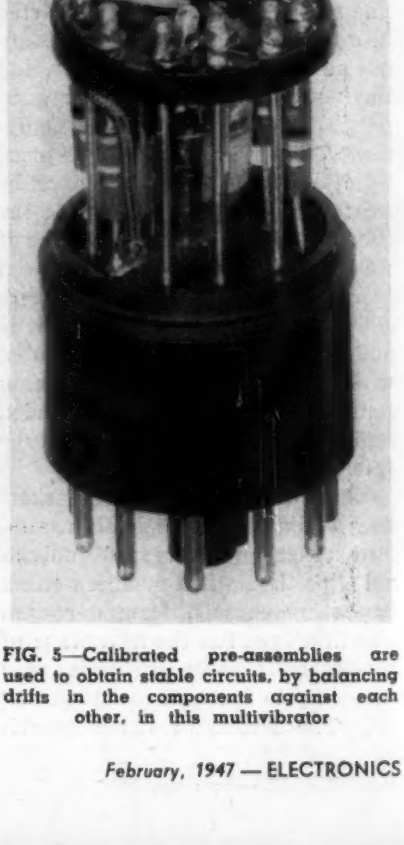
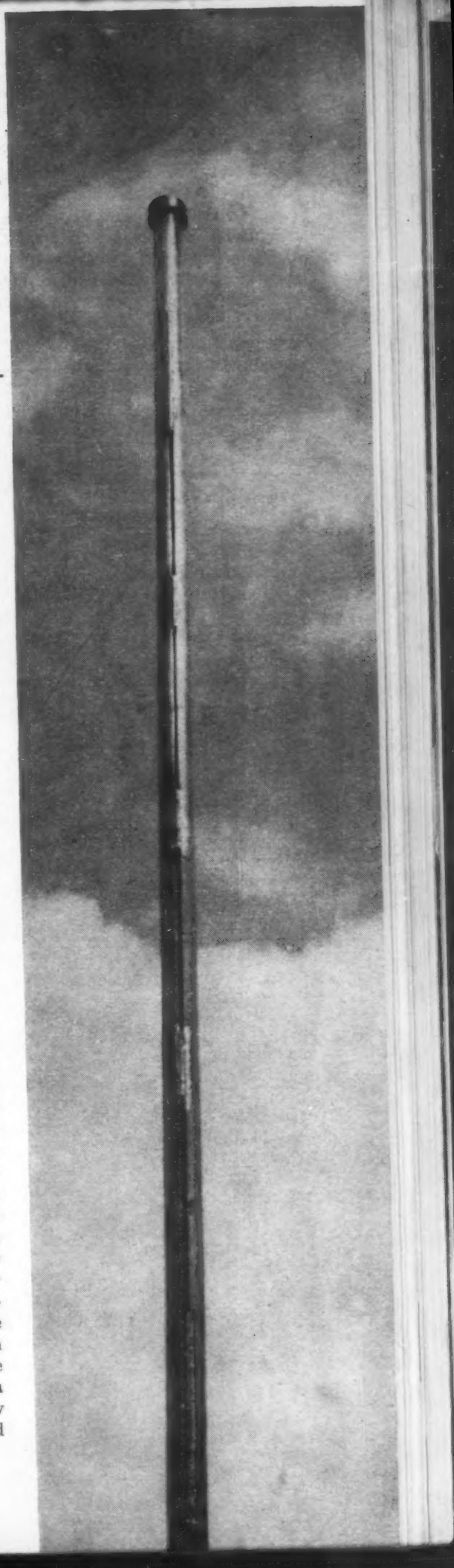


**FIG. 5—Calibrated pre-assemblies are used to obtain stable circuits, by balancing drifts in the components against each other, in this multivibrator**

# ANTENNA

By E. C. JORDAN and W. E. MILLER

*Department of Electrical Engineering*
*University of Illinois*
*Urbana, Illinois*



television, the slot-in-cylinder possesses considerable advantage over the ordinary dipole in these applications. A vertical slot has the desired vertical directivity with nearly uniform radiation in the horizontal plane and, in addition, has the correct polarization for f-m and television broadcasting.

When greater vertical directivity is desired, it can be obtained by stacking slots vertically as illustrated in Fig. 2. Because each unit of the array (that is, each slot) has considerable vertical directivity by itself and therefore radiation from any one element does not interact to a considerable extent with that from other elements, it is possible to space the units a wavelength apart without producing unduly large secondary lobes. Directivity of any array is proportional to its overall length; so when large spacing between units is permissible it is possible to have a long, and hence a highly directive, array without requiring an excessive number of units, simplifying feeding problems. The array of Fig. 2 has four slots, each three-quarters of a wavelength long, and spaced one wavelength center-to-center. When longer slots are used, larger vertical separations are permissible.

In Fig. 3 there are shown the measured vertical and horizontal patterns of the four-element array. Vertical directivity is very sharp and it is seen that most of the power is radiated within a few degrees of the horizontal. The excellent agreement between measured and theoretical patterns indicates that predicted gains can be closely attained in practice. In Fig. 3B there is also shown the relative field intensity in the horizontal direction produced by a pair of horizontal crossed half-wave dipoles fed with the same power as the four-slot array. Figure 4 shows the directed power gain of the slotted-cylinder array as a function of the number of three-quarter wavelength slots, spaced one wavelength apart. The gain shown is referred to that of a single half-wave dipole. The gain over a pair of crossed dipoles (as would be required to produce a uniform horizontal pattern with horizontal polarization) would be double that shown. The values given in Fig. 4 represent the average gain in the horizontal direction. For a one-eighth wavelength diameter cylinder, the horizontal pattern is not uniform and the actual gain is a little greater on the slot side of the cylinder and a little less on the side opposite the slots.

### Impedance Characteristics

In order to feed the slotted-cylinder antenna properly, it is necessary to know something of its impedance characteristics and how these characteristics vary with slot length and width, and cylinder diameter. Figure 5 shows resistance and reactance of a slotted cylinder as measured at the center of the slot. Impedance is shown as a function of slot length for various ratios of antenna diameter to wavelength. As cylinder diameter in wavelengths is made progressively smaller, the length of the slot required for resonance becomes very large, and there is a certain critical diameter below which resonance cannot be obtained

# SLOTTED - CYLINDER

**Simple mechanical construction, easily obtained vertical directivity, and horizontal polarization make the slotted-cylinder antenna ideal for f-m and television transmission and reception. Directivity and impedance characteristics for designing arrays are presented**

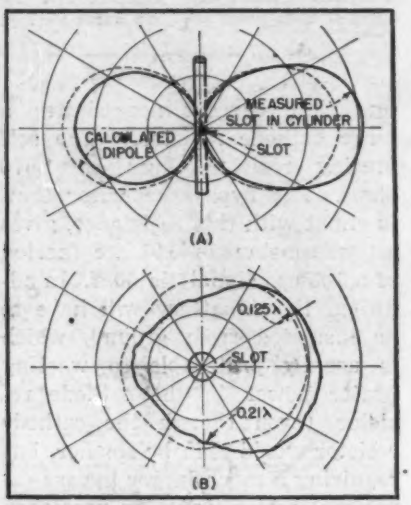



**FIG. 1—(A) Vertical radiation pattern of a three-quarter wavelength slot antenna compared to that of a half wavelength dipole, and (B) horizontal radiation pattern of slot antenna in a vertical cylinder of 0.21 wavelength diameter**

SLOT ANTENNAS have been successfully used on high speed aircraft to establish electric currents on outside surfaces of the metallic airplane structure and so make the aircraft itself the radiator. Examination of the characteristics of slot radiators shows that they possess properties that make them useful in many other applications as well.

In such applications a particularly useful form of the radiator is a slot cut lengthwise in a long, narrow, hollow cylinder. The first reference in the literature to this form of radiator appeared several years ago[1]. It proposed the use of a slit cylinder to guide or radiate electromagnetic waves. Slot radiators of one form or another have already found commercial application in frequency modulation[2] and television[3].

It is the purpose of this article to discuss some general properties of slot-in-cylinder radiators and to present radiation patterns and impedance curves that should enable engineers to determine the suitability of these antennas for applications in which they may be interested.

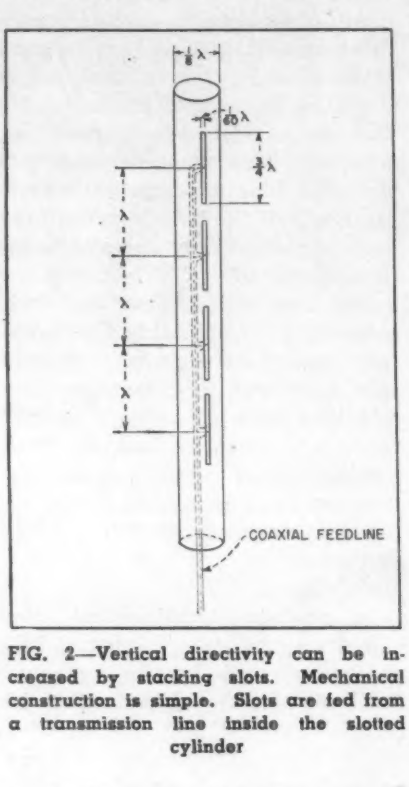



**FIG. 2—Vertical directivity can be increased by stacking slots. Mechanical construction is simple. Slots are fed from a transmission line inside the slotted cylinder**

### Radiation Patterns

Figure 1 shows the vertical and horizontal radiation patterns of a three-quarter wavelength slot cut in a vertical cylinder. For comparison, the vertical pattern of a half-wave dipole is also shown. For equal lengths, the vertical slot and vertical dipole have practically the same vertical radiation patterns. Length of the cylinder itself has no noticeable effect on the pattern. It must be long enough to accommodate the slot, but can be any convenient length longer. The horizontal pattern of the vertical slot-in-cylinder is dependent upon the diameter of the cylinder. In general, radiated field intensity is greater on the side on which the slot is located than it is on the opposite side of the cylinder. However, for cylinder diameters of about one-tenth wavelength or less, radiation in the horizontal plane is essentially uniform.

The radiation pattern of a slot in a narrow cylinder is almost the same as that of the corresponding length dipole, but with one important difference: the electric field produced by a vertical dipole is vertically polarized whereas that produced by a vertical slot is horizontally polarized. Because horizontal polarization is used for both frequency modulation and

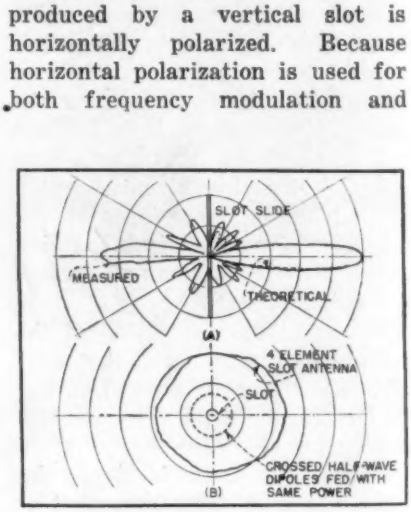



**FIG. 3—(A) vertical, and (B) horizontal radiation patterns of slotted-cylinder array shown in Fig. 2**

at any slot length. For the particular slot width used in this case, this critical diameter appears to be about 0.11 wavelength. It will be noticed that the resonant length (that is, the length for zero reactance) is very long for narrow diameter cylinders, but becomes smaller as the cylinder diameter increases. For larger diameter cylinders, second resonance points appear at slot lengths roughly double that for the first resonance. Resistance at this second resonant point is comparatively low, being of the order of 40 ohms, while at the first resonant point it ranges between 300 and 1,000 ohms. The effect of greater slot width is to increase the length of slot required for resonance for a given cylinder diameter.

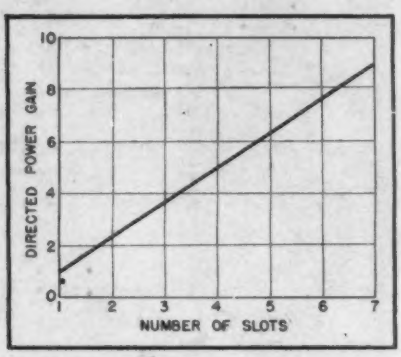



**FIG. 4—Concentration of power in the vertical plane, relative to that from a dipole, for an array similar to that of Fig. 2**

### Explanation of Operation

There are two rather simple physical pictures which can be used to explain the operation of the slot-in-cylinder antenna. The first considers the edges of the slot as constituting a parallel-wire transmission line which is shorted at both ends.

A voltage is applied across the transmission line (usually, but not necessarily, at the middle) and standing waves of voltage and current are set up along the line. Because of the close spacing between the edges of the slot, transmission line currents would not be expected to radiate appreciably. However, the slot transmission line has connected to it the remainder of the cylinder which has a twofold effect.

In the first place, the voltage across the slot causes currents to flow around the outside of the cylinder and these currents flowing in the circular path radiate appreciable amounts of power, the diameter of the path being a significant fraction of a wavelength. In addition, the cylinder acts as an inductive reactance shunted across the slot transmission line, and so modifies the phase velocity and hence the wavelength along the line. From transmission line theory it is known that inductive shunt loading will increase both phase velocity and wavelength, and so increase the line length required for resonance. If the loading is too great (that is, if shunt inductive reactance is too low) wave motion along the line ceases and the loaded line acts as an attenuating network.

This simple picture serves to explain most of the characteristics of the impedance curves for narrow cylinders. For larger diameter cylinders it is necessary to resort to waveguide theory for the second physical picture. The inside of the cylinder is a degenerate cylindrical waveguide.

Within a waveguide the phase velocity and wavelength are always greater than the corresponding free-space quantities and the ratio of wavelength in the guide to free-space wavelength becomes very large as the diameter of the cylinder decreases to the cutoff diameter. For completely closed cylindrical waveguides the cutoff diameter for the dominant mode is 0.586 times the wavelength, but when the cylinder has a slot in it, with the excitation applied across the slot, the cutoff diameter is very much less than this value. In this latter case the capacitance of the slot reduces the required diameter of guide in much the same way as the length of a transmission line section required for resonance is reduced by capacitive loading of the load to which it is connected. It is apparent that the greater the capacitive loading (that is, the narrower the slot) the smaller will be the cutoff diameter of the cylinder.

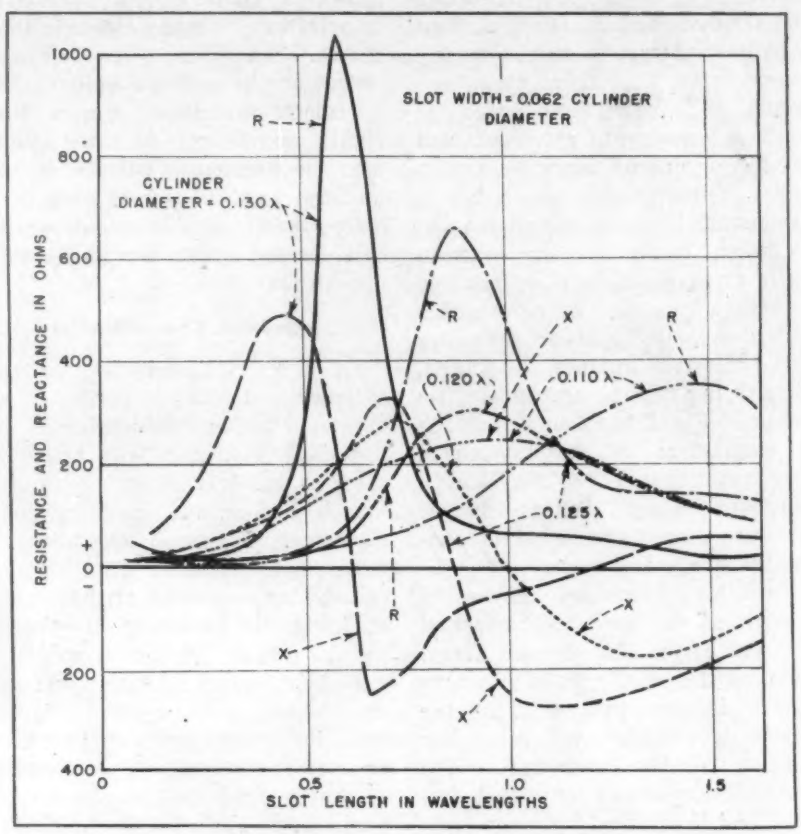



**FIG. 5—For a slot representing a fixed fraction of the cylinder diameter, resonant impedance increases and resonant slot length approaches a half wavelength as cylinder diameter is increased**

With slot widths used in making the measurements shown, cutoff diameter was of the order of one-tenth wavelength. With narrower slots, or slots the sides of which overlap, cutoff diameter can be reduced to one-thirtieth of a wavelength or less.

Figure 6 shows the electric field intensity across the slot, measured for several cylinder diameters. For large diameters the distribution of electric intensity along the slot is closely sinusoidal with the distance between nodal points only slightly greater than the free-space half wavelength. However, as the cut-off diameter is approached the distance between nodal points becomes relatively larger, attenuation within the guide increases and the distribution changes from sinusoidal to exponential. Figure 7 gives the ratio of wavelength in the guide to wavelength in free space for various cylinder diameters. From the curve or the field distributions on Fig. 6 one can determine the maximum slot length which can be used to give a single lobe in the radiation pattern. Figure 8 shows slot length required for first resonance as a function of cylinder diameter.

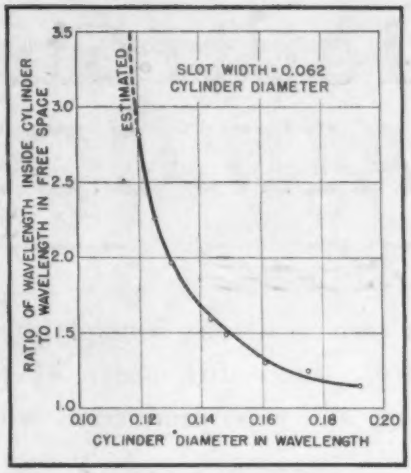



**FIG. 7—Resonance phenomena presented in Fig. 5 and 6 can be summarized as a curve of ratio of inside to free-space wavelengths**

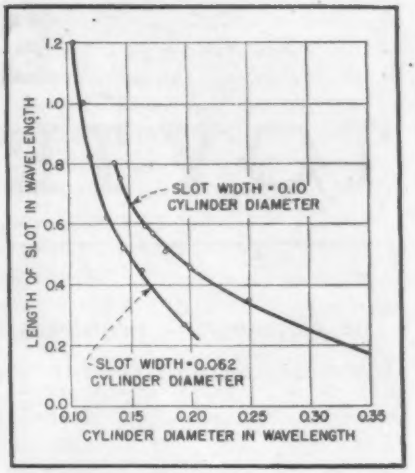



**FIG. 8—Design of slotted-cylinder antenna involves choosing cylinder diameter and slot width that give reasonable slot length at the operating frequency**

### Methods of Feed

The slotted-cylinder antenna can be fed by either coaxial or parallel-wire transmission lines running up the inside of the cylinder. Both of these methods were used in obtaining the measurements shown. Choice between a single or double coaxial line or parallel-wire line feed depends upon convenience and impedance-matching possibilities.

The impedance around the second resonant point is low, indicating coaxial-line feed in this region of operation. At the first resonant point the impedance is high and parallel-wire feed inside the cylinder is preferable. However, lower impedances can be obtained by feeding the slot off-center. With an array of slots at one wavelength spacing, slot impedances are effectively in parallel and for a four-slot array operating at the first resonance, the input impedance of the transmission line is of the order of 100 ohms.

It is evident from the discussion on theory of operation that large variations in impedance can be obtained by adjusting the effective capacitance across the slot. The effective slot capacitance will depend primarily on slot width, but will also depend somewhat on the thickness of the cylinder wall. For impedance curves shown, a cylinder wall thickness of approximately 1.5 percent of the cylinder diameter was used.

Bandwidth measurements on the slotted-cylinder antenna indicate bandwidths at the first resonance of between four and eight percent (between frequencies at which the standing-wave ratio on the feed line was two to one). The bandwidths around the second resonance points were not measured, but a study of the impedance curves indicates that they should be considerably wider than at the first resonance points.

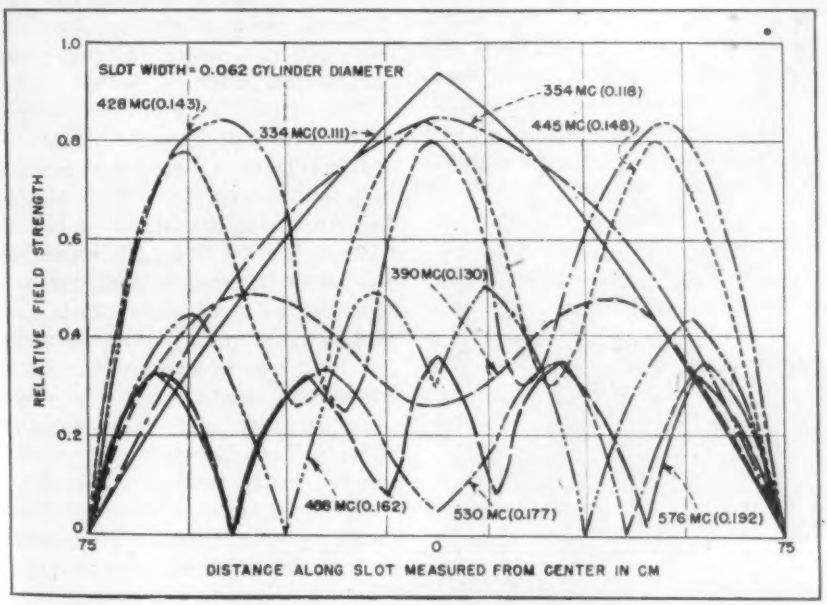



**FIG. 6—Field strength distribution along a 150-cm slot varies with frequency because of the change in velocity of propagation along the radiator. Numbers in parentheses indicate cylinder diameter in wavelengths**

### References

(1) Blumlein, A. D., High Frequency Electrical Conductor or Radiator, U. S. Patent No. 2,238,770, April 15, 1941.
(2) Alford, A., Antenna for F-M Station WGHF, *Communications*, p 22, February 1946.
(3) Color Television on Ultrahigh Frequencies, ELECTRONICS, p 109, April 1946.

# Electronic TOY-TRAIN CONTROLS

**The engineering problems in carrier-current control of model railroads rival those in telemetering and remote control. Successful design of system components capable of hard usage and mass production is described**

**By JOSEPH L. BONANNO**

*Chief Engineer*
*Lionel Corp.*
*Irvington, N. J.*

THE problem of remote control has always taxed the ingenuity of miniature railroad enthusiasts. Literature and patent office files are replefe with devices of various degrees of complexity, ranging from purely mechanical trip mechanisms to electronic circuits, all intended to lend verisimilitude to the operation of toy trains. A genuine remote operation of miniature railroads became possible only with the recent development of an electronic system of control.

While there is nothing novel in the application of electronics to remote control apparatus—such systems have been used for over two decades in drone aircraft and elsewhere—the adaptation of electronic control to miniature railroads presented a number of design problems.

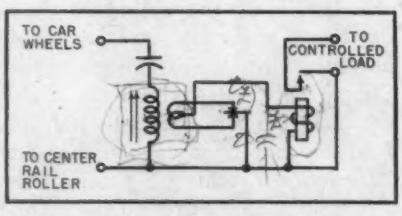
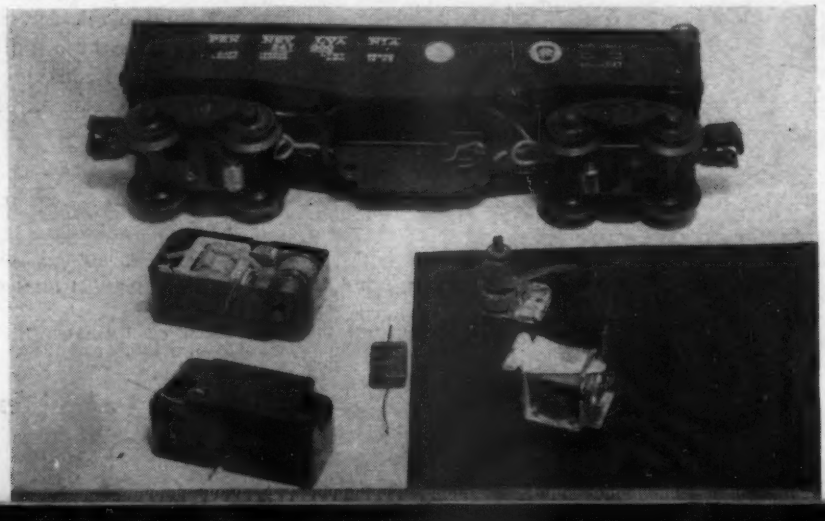



**FIG. 1—Schematic wiring diagram of the receiver. Relay contacts are factory adjusted**

Paramount is the problem of size. Each receiving unit must be self-contained and small enough so that it can be conveniently and inconspicuously mounted within the miniature rolling stock. Equipment must be rugged to withstand the vicissitudes of model railroading. It needs stability within a wide range of operating conditions, and interchangeability with a minimum of adjustment. And, of course, it must be inexpensive and suitable to mass production technique.

**Gondola car showing mounting of receiver. Complete receivers are shown in left foreground with tuning unit and relay at right**



### Receiver Design

The use of miniature vacuum tubes was considered in the early stages of receiver development but rejected principally because of the problem of plate and filament supply. While a miniature step-up transformer and metallic rectifier pile could easily be built, the operating track voltage—which would serve as the power source—normally ranges between 6 and 18 volts. So wide a variation in the power supply, as well as the cost, rendered the use of vacuum tubes impractical in the receivers.

The circuit selected for the receiving stations is an r-f series circuit utilizing a small commercial type mica capacitor and a miniature permeability-tuned inductor. The high r-f voltage developed at resonance across the inductor coil is stepped down in a center-tapped secondary winding, and then rectified by means of two metallic rectifiers. Sufficient power is thus obtained from the r-f signal to operate a sensitive d-c relay in the power circuit, shown in Fig. 1.

Of the several types of metallic rectifiers investigated, copper oxide instrument type discs proved the most practicable, principally because their resistance was of an order of magnitude that can be matched to a convenient size 500-

Test setup for adjustment of two receivers in locomotive tender, one for controlling locomotive and one to operate whistle. Spring assembly in foreground provides predetermined mechanical load for couplers

ohm relay. Selenium rectifiers, while satisfactory in most respects, were rejected because they were not at the time readily available in instrument sizes. Their relatively higher resistance would also have required a higher impedance relay, having a poorer winding space factor, and lower power sensitivity.

### Frequency of Operation

The first experimental outfit was built to operate within the range of 50 to 80 kilocycles. Further tests proved, however, that the capacitance of the rectifier discs did not unduly load the output until frequencies of the order of 500 kc were reached. Consequently, the frefrequency channel was raised to between 240 and 360 kc, which while still low enough to avoid interference in the standard broadcast band, reduced further the size and cost of the components.

Two other considerations influenced the selection of the upper frequency limit. When higher frequencies were employed, stability of individual components became too critical for economical production. Further, the shorter wavelengths fall within the order of magnitude of practical track layouts with the consequent danger of creating standing waves at points along the track.

Possibly the key to a successful receiver circuit without vacuum tubes, amplifier, or volume control is the design of a compact and relatively inexpensive relay operating reliably on 6 milliwatts and handling currents up to 4 amperes at 18 volts for at least 10,000 operations. The design of this relay constituted a major part of the receiver development. To achieve the necessary sensitivity, the relay is maintained within close limits of mechanical tolerance.

To provide a simple and compact means of adjustment the lower contact was designed in the form of an eccentric disc which can be rotated to properly regulate the magnetic air gap. Because the armature spring restoring force at the contact points is only 1.5 grams, special nonwelding contact material had to be found. A solid palladium silver disc proved to be the solution.

The exigencies of space also resulted in the design of a novel jarproof, self-locking permeability adjustment illustrated in Fig. 2. A molded tube serves as a channel for the movement of the pressed iron tuning plunger. The upper end of the tube is slotted and threaded. A split retaining ring forced over the slotted end of the tube maintains a continuous locking pressure upon the adjusting screw regardless of the thread wear. The outside of the tube serves as mounting for the coil and the same molding contains nests for the miniature rectifier discs which are kept in position by means of a metal contact plate crimped to the molding.

The receiver unit as finally developed operates with an overall system efficiency of 8 percent and is housed together with the relay within a molded plastic housing measuring $1 \times 2\frac{1}{4} \times \frac{7}{8}$ inches, or almost exactly the volume of a safety match box. A typical resonance curve is shown in Fig. 3.

The criteria of low cost and high order of frequency stability under a wide range of operating conditions also governed the design of the transmitter. Early determination of power requirements revealed that the r-f shunting effect of motors, solenoids and other operating equipment containing windings either with or without iron cores was negligible; the only serious problem was offered by lamps.

The average lamp used in miniature railway layouts operates on 12 volts and consumes $\frac{1}{4}$ ampere. Assuming a maximum of 20 lamps in parallel, the total hot lamp resistance approximates 2.5 ohms. To this resistance, however, is added track and contact resistances and lead impedances so that the maximum r-f impedance is seldom less than 10 ohms under the most adverse operating conditions. To maintain good voltage regulation the transmitter output is matched to 1.5 ohms. Since power requirements thus do not exceed 0.6 watt, it is possible to employ a type 117 diode-pentode which develops one watt of power and operates directly from the line.

The power leads normally connecting the track layout to the variable low-voltage transformer offer an easy solution to the transmission problem. A wired wireless system has been adopted, and the r-f transmitter output superimposed directly on the train power circuit,

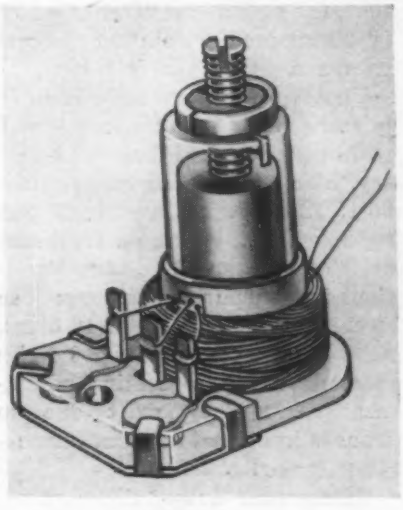


FIG. 2—Drawing of the receiver proper showing split lock ring at top, adjustable tuning core and tuning coil. The rectifier discs are under the contact plate tabs to left and center

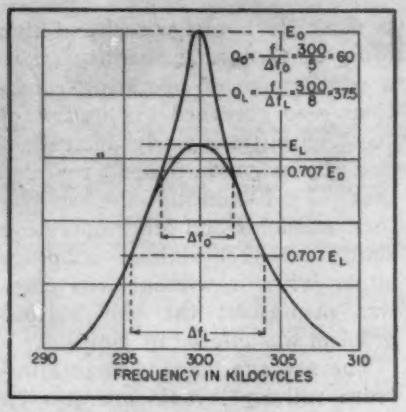



**FIG. 3—Receiver resonance curve. $E_0$ is open circuit voltage; $E_L$ is voltage with circuit loaded by 500-ohm relay**

with connection as shown in Fig. 4. The transformer output winding, which acts as an r-f choke, is effectively bypassed by a 0.1 $\mu$f capacitor.

While oscillating circuits that are not crystal controlled are ordinarily considered unstable, it was found that by proper selection of circuit constants frequency is maintained within 0.1 percent. Transmitters are thus completely interchangeable. To achieve this result the tank circuit mica capacitors selected within 3 percent tolerance, are shunted by a trimmer for accurate setting under load of final frequency value. These capacitors, as well as the receiver capacitor, receive Class C RMA treatment to prevent drift due to aging. The tapped oscillator tank coil is wound upon a machine-threaded phenolic tube, the outside diameter of which is maintained within 0.2 percent tolerance.

These precautions have resulted in transmitter stability that is well within the required limits of accuracy. Variation of line voltage from 90 to 125 volts has a scarcely perceptible effect, causing a frequency drift of less than 30 cycles. Variations in transmitter load from open circuit up to maximum of 10 ohms, shift frequency not quite 400 cycles from its normal operating adjustment. Frequency drift due to changes in normal ambient temperature is negligible.

Transmitter output distribution, shown in Fig. 5, is relatively flat over the entire transmitter range even under maximum track loading. Since the vacuum tube plate voltage is applied only when the transmitter is in actual operation, the normal tube life of 500 hours is extended considerably. Interchanging tubes has negligible effect upon the transmitter frequency because of the large circuit capacitances.

Ten taps on the oscillator tank coil, each connected to a separate contact button on the control panel illustrated, provide ten fixed operating frequencies in steps varying geometrically from 11.3 to 18.7 kc. For easier identification, each control button, in addition to being numbered, is molded in a distinctive color plastic which corresponds to a like-colored disc upon its "drone" car. A standard electronic control outfit contains six receivers, one to control the locomotive reversing unit, one to operate the train whistle and the remaining four to trigger the electromagnetic couplers on each of the four cars. The transmitter therefore furnishes four spare channels that may be used for additional equipment, or to operate several trains independently on the same railroad system.

### Auxiliary Switching

The utility of the receivers has been extended by auxiliary switching mechanisms, such as a thermal delay switch incorporated in the automatic dump car to save an additional receiver. In this device a V-shaped bimetal strip in series with the couplers closes the dumping circuit when the transmitter button for that car is held down a few seconds. The use of a step or a sequence switch, such as employed in the locomotive reversing unit, permits any number of sequence operations to be controlled by one receiver.

Because satisfactory operation of the system depends not only on the accurate setting of the transmitter frequencies and the proper sensitivity range of the relays but also upon the delivery of constant voltage to the receiver input terminals, it is sometimes advisable to reduce r-f losses in the track itself by employing auxiliary lamp cord feeders, spacing them approximately 20 feet apart along the track.

There is no direct interference with radio receivers since the fundamental transmitter frequencies are well below the commercial broadcast band. It has been found, however, that second and third harmonics can be picked up by a sensitive set located in the same room, despite the fact that the miniature track layout is in effect a closed nonradiating parallel wire system. Since the harmonic content is negligible the problem is not serious. Transmitter radiation is well within the allowable FCC limit.

An interesting sidelight of the electronic control system has been the development of an electromagnetic railroad knuckle-type coupler which makes it possible for two adjacent cars to be uncoupled by opening either of the mating couplers.

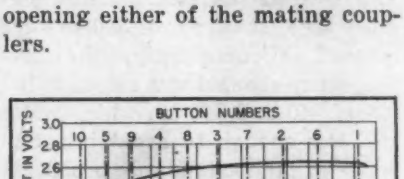



**FIG. 5—Graph of transmitter output into a 12-ohm load for different frequencies**

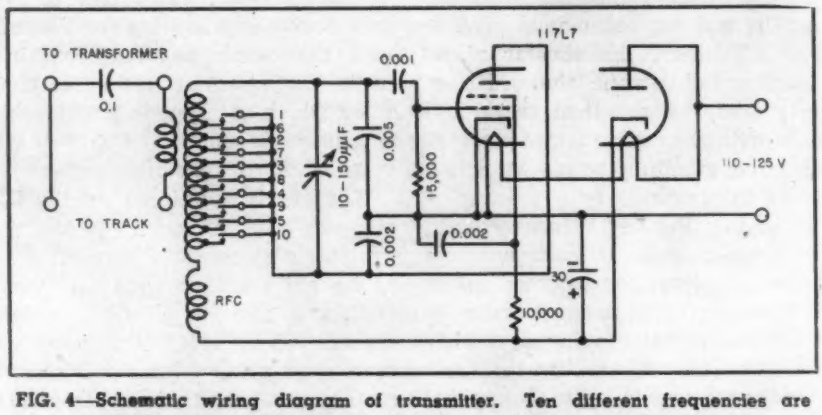



**FIG. 4—Schematic wiring diagram of transmitter. Ten different frequencies are available using pushbuttons to select them and to turn on plate current**

# Pulse-Type Tester for High-Power Tubes

**Motor-driven 5-rpm commutator in simple trigger circuit causes ignitron to fire and apply high-voltage pulse to grid of tube being tested. Resulting grid and plate voltage and current pulses are measured on high-persistence c-r tube by means of calibrating spot**


**By E. C. EASTON** and **E. L. CHAFFEE**

*Assistant Professor of Electrical Engineering*
*Graduate School of Engineering, Harvard University*
*(Formerly of Cruft Laboratory)*

*Professor of Applied Physics*
*Director of Cruft Laboratory*
*Harvard University, Cambridge, Mass.*


THE purpose of the pulse-type high-power tube tester herein described is to obtain simultaneous measurements of plate voltage, plate current, grid voltage, and grid current at the crest of the grid-current curve of a triode when the grid current is made to vary as a pulse of very short duration.

An electrically operated commutator alternately applies to a cathode-ray oscilloscope a signal from the tube tester or a signal from a calibrating circuit. When the tube tester is connected to the oscilloscope, a voltage proportional to the grid current is applied to the horizontal plates while the vertical deflection is produced by either the plate voltage, plate current, or grid voltage as desired. The operator obtains readings of the peak values by matching a calibrating spot with the end of the characteristic curve as seen on the long-persistence screen of the oscilloscope.

The apparatus was designed to test tubes of the type used for loran. The tube can be supplied with plate-current pulses of 200 amperes at plate voltages up to 20,000 volts. The grid voltage may be varied from −5,000 to +10,000 volts.

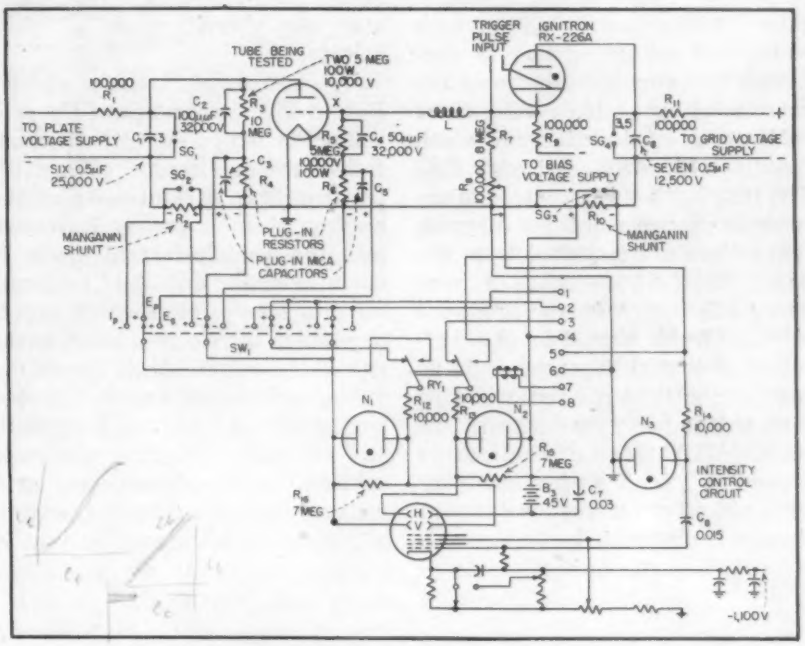



**FIG. 1—Measuring circuit for pulse-type tube tester**

### Measuring Circuit

The measuring circuit is shown in Fig. 1. The grid current is measured in terms of the voltage across a noninductive shunt $R_{10}$. This voltage is applied directly to the horizontal plates of a cathode-ray oscilloscope. The plate current is measured in similar fashion by applying directly to the vertical plates of the oscilloscope the voltage across the noninductive shunt $R_2$. By means of switch $SW_1$, the vertical plates may be connected either across $R_2$ for plate current measurement, across $R_4$ for plate voltage indications, or across $R_6$ for determining the grid voltage. Complete shielding of all portions of the measuring circuits is most essential in this method because of the use of pulses having high rates of change of current.

The combination $C_2C_3R_3R_4$ forms a compensated voltage divider to supply a known fraction of the plate voltage to the oscilloscope. Similarly, $C_4C_5R_5R_6$ form another compensated voltage divider for the measurement of grid voltage. Each voltage divider is carefully adjusted with the aid of a square-wave generator so that when a square wave of voltage is applied across the divider, a good

reproduction of the square wave appears across the low-voltage section.

The high-voltage section of each divider is enclosed in an aluminum shield. The low-voltage section plugs into sockets mounted on the shield. The shield and the bottom of the low-voltage section are grounded to a common point which also serves as the ground connection for the tube to be tested, the cage which holds the apparatus, and the shunts $R_2$ and $R_{10}$. By the use of a common ground point, ground currents are kept out of the cage and shields, and thus magnetic disturbances from ground currents are minimized.

Connections from the voltage dividers and shunts to the oscilloscope are made through coaxial cable. The grounded side of each shunt and voltage divider is connected to the outer conductor of the corresponding cable. All these cables run to a junction box which contains switch $SW_1$ and relay $RY_1$. The junction box is grounded to the common ground point, but all cable connections are insulated from the box. Thus, if, because of very heavy tube currents, the grounded side of a cable should be at a different potential from ground, no part of the tube current will flow through the outer conductor of the cable. With these precautions in grounding and shielding, no magnetic pickup or interaction between circuits is observed.

The impulse of grid current is controlled by the ignitron RX-226A. When the trigger circuit causes the ignitron to fire, the voltage on capacitor $C_6$ is applied between grid and cathode of tube $X$. The inductance $L$ retards the rise and fall of grid current sufficiently to provide a grid-current pulse which rises rapidly and then holds a rounded peak for several microseconds before dropping.

### Pulse-Forming Circuit

Before the ignitron is fired, the grid of the tube $X$ is kept at a negative potential by a bias power supply acting through $R_9$. This negative bias is adjustable to a maximum of 5,000 volts and is set at a value sufficient to hold the plate current to a negligible value over the normal range of plate voltage.

By means of voltage divider $R_7R_8$ in Fig. 1, a portion of the grid voltage is fed to the intensity control of the oscilloscope. When the ignitron fires, the intensity of the electron beam is greatly increased, and the rapidly-formed trace is made visible on the long-persistence screen. (Battery $B_3$ serves to position the electron beam to the left of the center of the screen.)

The oscilloscope beam is deflected horizontally by the grid current, and vertically by either the plate voltage, plate current, or grid voltage, depending on the setting of $SW_1$. When the grid current is at its peak, the beam is deflected to a maximum horizontally. Hence, if observations are made on each vertical signal at the extreme of the horizontal deflection, all readings are obtained at the peak of the grid current.

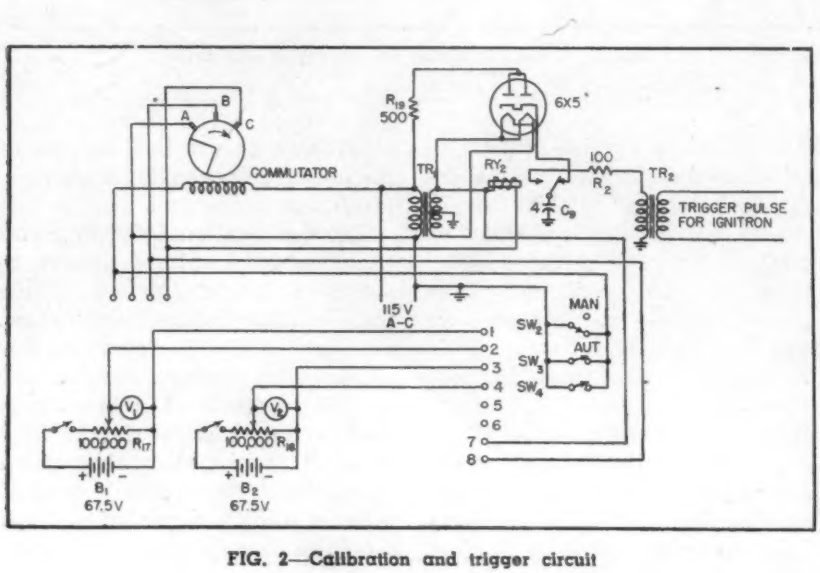



FIG. 2—Calibration and trigger circuit

### Calibration Procedure

In order to calibrate the oscilloscope and thus obtain the true value of each measured quantity from the deflection on the screen, two variable d-c voltages are provided, as shown in Fig. 2. By means of battery $B_1$, potentiometer $R_{17}$, and voltmeter $V_1$, a known voltage of any desired value can be applied to the vertical plates; $B_2$, $R_{18}$ and $V_2$ supply a similar known adjustable voltage for the horizontal plates. When relay $RY_1$ is in the position shown in Fig. 1, these calibrating voltages are applied to the oscilloscope.

By adjusting $R_{17}$ and $R_{18}$, the luminous spot may be moved to any point on the screen. Thus the spot may be moved to the end of the signal trace, and by reading $V_1$ and $V_2$, the vertical and horizontal deflection voltages can be determined at the peak of the grid current. Knowing these deflection voltages and the resistance of shunts $R_2$ and $R_{10}$, the plate and grid currents may be found. Similarly, knowing the voltage divider ratios, the plate and grid voltages may be determined.

In order to keep the outer conductors of all coaxial cables at ground potential, it is necessary to have the plate and grid voltages cause a deflection in the opposite direction from that caused by the plate current. Switch $SW_1$ reverses the polarity of the calibrating voltage whenever the polarity of the signal voltage changes.

Relay $RY_1$ switches the oscilloscope from signal to calibration. When the relay is energized, the signal is fed to the oscilloscope. When the relay coil current is removed, the oscilloscope is connected to the calibrating voltages.

The operation of relay $RY_1$ is controlled by the trigger circuit shown in Fig. 2. This circuit includes a mechanical commutator having three contacts. The commutator rotates at 5 rpm. The

rotating Bakelite disc contains a brass insert which connects the contacts with each other as the disc turns. When contacts *A* and *B* are connected by the brass insert, relay $RY_1$ is energized by transformer $TR_1$, and the measuring circuit is connected to the oscilloscope.

When all three contacts are connected together, relay $RY_2$ is energized. This relay causes $C_9$ to discharge through the primary of transformer $TR_2$. The pulse of voltage from the secondary of $TR_2$ fires the ignitron and thus applies the grid voltage to tube *X*. As the commutator continues to rotate, both $RY_1$ and $RY_2$ are deenergized, and the calibration voltages are applied to the oscilloscope. Thus, five times a minute, the following cycle of operations takes place: $RY_1$ closes, $RY_2$ closes, the ignitron fires, $RY_1$ and $RY_2$ open. With $RY_1$ closed, the operator sees the tube characteristic on the oscilloscope screen. With $RY_1$ open, he sees the spot as positioned by the calibrating voltage.

The operation of the mechanical commutator is made automatic by setting switch $SW_2$ in Fig. 2 on AUT. When this switch is open (position indicated as MAN) the commutator does not rotate. With $SW_2$ open, the operation of the commutator may be controlled manually by pushbutton $SW_3$ on the main panel, or by $SW_4$ which is a remote trigger mounted at the end of a long cord. The 6X5 tube shown in Fig. 2 is a rectifier which charges $C_9$.

### Protective Devices

To insure the safety of both operator and equipment, various protective devices are provided. In Fig. 1, $N_1$, $N_2$ and $N_3$ are ¼-watt neon bulbs. Should a flashover occur in any of the high-voltage circuits these neon bulbs together with resistors $R_{12}$, $R_{13}$, and $R_{14}$ will prevent the voltages applied to the oscilloscope from exceeding a value of approximately 70 volts.

Spark gap $SG_1$ is set to break down at 20,000 volts in order to protect $C_1$, which is rated at 25,000 volts. Gap $SG_4$ breaks down at 10,000 volts to protect the 12,500-volt capacitors at $C_8$.

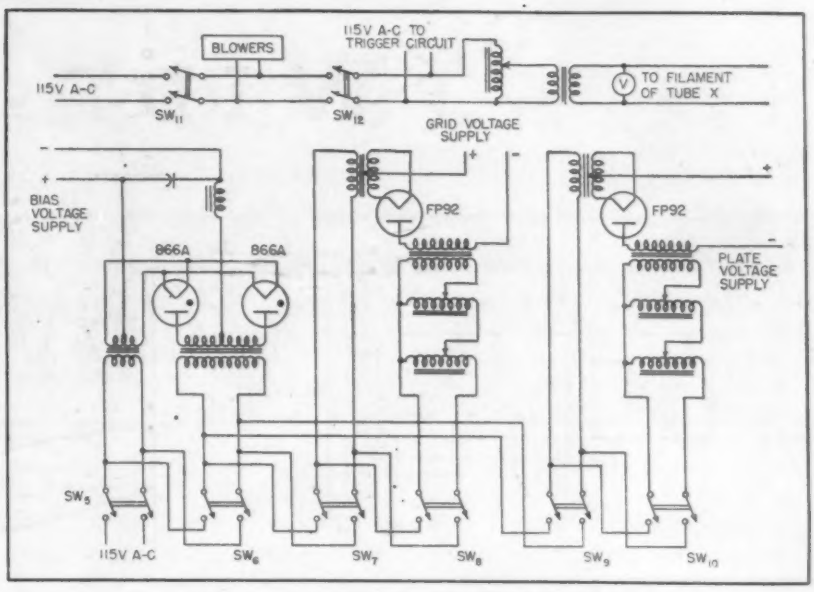



FIG. 3—Power system for pulse-type tube tester

Paper gaps $SG_2$ and $SG_3$ are designed to break down and form a mechanical short-circuit if excessive voltage should appear across either shunt $R_2$ or $R_{10}$. These gaps each consist of a spring whose pointed end presses against a brass plate. A piece of thin paper is placed between the point and the plate. If excessive current should be passed through the shunt, the paper is punctured, the spring makes contact with the plate, and the shunt is short-circuited.

In order to prevent the operator from applying plate voltage to tube *X* before the negative grid bias is connected, the power controls are interlocked as shown in Fig. 3. Closing switch $SW_5$ applies filament voltage to the 866A mercury-vapor tubes in the bias power supply. This switch also supplies voltage for $SW_6$. Closing $SW_6$ applies plate voltage to the bias rectifier and thus provides the negative bias for tube *X*. After $SW_6$ is closed, voltage is available for the grid and plate power supplies.

The use of two autotransformers in the high-voltage parts of the grid and plate power supplies is an added safety feature. In each system, one autotransformer is placed out of the operator's reach and is set so that when the second autotransformer is adjusted by the operator, no dangerously high voltages may be applied to the tube *X* at any setting of the operator's control transformer.

Switch $SW_{11}$, mounted on the main panel, turns on the blowers which cool tube *X* and also provides voltage for $SW_{12}$. Closing $SW_{12}$ applies voltage to the filament of tube *X* and also provides voltage for the trigger circuit.

When the tube tester is used for making measurements, it is advisable to keep the oscilloscope signal voltages between 25 and 50 volts. Voltages below 25 give deflections whose short length increases errors in measurement. Voltages much in excess of 50 volts may cause the neon protective bulbs to ignite and give a false indication.

To keep the oscilloscope voltages within the required range when measuring grid or plate voltages, each voltage divider is provided with several different low-voltage sections. Thus, the plate-circuit voltage divider has four low-voltage sections providing voltage ratios of approximately 50, 100, 200, and 400. These ratios cover the voltage ranges 0-2,500, 2,500-5,000, 5,000-10,000, and 10,000-20,000 respectively.

Similarly, shunts of different value are provided for $R_2$ and $R_{10}$. For $R_2$ the available resistances are approximately 2, 1, 0.5, and 0.25 ohms covering the current ranges 0-25, 25-50, 50-100, and 100-200 amperes respectively.

# WIDE-ANGLE

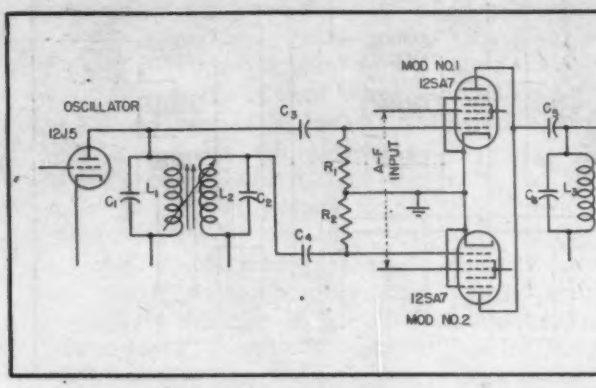



FIG. 1—Basic modulator consists of a phase-shifting network feeding two differential amplitude-modulating tubes. The vector output is phase modulated

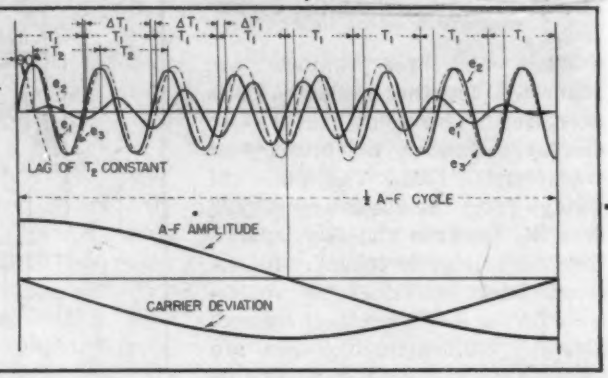



FIG. 2—Addition of two components of varying amplitude and constant phase difference gives a signal of constant amplitude and varying phase position

**By H. K. BRADFORD**

*Assistant Project Engineer*
*Communication and Navigation Dept.*
*Bendix Radio Division*
*Bendix Aviation Corp.,*
*Baltimore, Md.*

A FREQUENCY-MODULATION system was developed concurrently with amplitude-modulation equipment for railroad communication so that its advantages could be made known to the railroads. The equipment was designed so that conversion from one type of modulation to the other would be as simple as possible. While the amplitude-modulation system is conventional, the frequency-modulation system offers some interesting aspects.

### Phase-Shift Modulation

The phase-shift method of modulation was chosen for this mobile equipment so that direct crystal control could be used for the carrier. The use of a master oscillator with correction circuits necessary for the frequency stability required in the vhf band of 152 to 162 mc was regarded as impractical. With phase-shift modulation, the carrier is derived from a crystal oscillator, the frequency of which remains unchanged in the process of modulation.

With reactance-tube frequency modulation the base or oscillator frequency can be changed as much as desired within the circuit capabilities, but with phase-shift modulation we do not change the base or oscillator frequency, we continuously shift the phase of a frequency component derived from the oscillator. The oscillator component is never completely detached from the multiplier-amplifier following it so its component is always part of the driving force. For this reason the phase shift is limited to an amount which will not seriously change the driving amplitude.

For example, if the phase shift becomes as much as 180 degrees, the derived phase component will cancel the normal oscillator component and there will be no output, providing that the amplitudes are equal. This fact restricts the angle of phase shift to an amount which, with the oscillator component, will not seriously affect the total amplitude used to drive the multiplier-amplifier. For a complete discussion of the theory of various forms of angle modulation refer to Frequency Modulation by W. L. Everitt, *A. I. E. E. Trans.*, Nov. 1940, p 613.

For the purpose of this discussion we will regard phase-shift modulation as adding or subtracting increments of time throughout each r-f cycle. If equal increments of time are added to each cycle, the resultant frequency will be lower than before and constant. However if we add increasingly larger increments of time to succeeding r-f cycles, the frequency reduces in accordance with the sizes of these increments. If the increments are proportional to sine functions, those at the beginning of the modulating cycle will be largest, displacing the frequency by the greatest degree, while those toward 90 degrees of the modulating cycle will tend toward zero, at which time the r-f will return to normal frequency. The carrier deviation is proportional to the rate at which these time increments increase or decrease and not to their magnitude.

If the phase between two carriers remains constant they will have the same frequency regardless of the amount by which their phase differs. Thus if time (and hence phase) increments follow a sine-

# PHASE MODULATOR

**Technique for phase modulating a crystal-controlled carrier, whereby two components of fixed phase difference are amplitude modulated and added to give the output, is described. Circuit can be used to give frequency modulation, or modified to give amplitude modulation**

wave form, their rate of change will follow a cosine form. If these increments follow a transient form, their rate will follow as their first differential.

### Modulation Relationships

If we define the instantaneous voltage of a sine wave as

$$e = E_0 \sin \omega t \qquad (1)$$

we must realize that the angular velocity $\omega t$ is changing in frequency modulation according to one law for the reactance tube and according to another for the phase-shift method. Suppose that we are to phase-shift modulate with another sine wave defined as $E_1 \sin \omega_1 t$, then the angle $\omega t$ in Eq. 1 would have to be altered as $\omega t + E_1 \sin \omega_1 t$. However the amplitude here defined as $E_1$ has the meaning that a maximum number of degrees or radians of angle is to be added to or subtracted from the original angle $\omega$. The circuit analysis to follow will show that the a-f amplitude $E_1$ produces a proportional phase shift. If it is more convenient to regard $\omega t$ as a rotation, then the addition of $E_1 \sin \omega_1 t$ simply means that this rotation is periodically accelerated and decelerated by an amplitude $E_1$ and a period $\omega_1 t$. If $E_1$ is actually a maximum angle set by the design of the equipment, it may be designated more properly as an angle $\phi$ in which case the entire equation for a phase-modulated wave becomes

$$e = E_0 \sin (\omega t + \phi \sin \omega_1 t) \qquad (2)$$

Because we are not immediately interested in the energy distribution in the radio spectrum it is possible to make a very simple analysis of Eq. 2.

The part of the total carrier angle $\omega t + \phi \sin \omega_1 t$ which accounts for modulation only is $\phi \sin \omega_1 t$. Moreover, we have just found that it is the rate of change of this expression which determines the frequency deviation of the carrier, hence

$$2\pi\Delta f = \frac{d(\phi \sin \omega_1 t)}{dt} = \omega_1 \phi \cos \omega_1 t$$

$$= 2\pi f_m \phi \cos \omega_1 t$$

$$\Delta f = f_m \phi \cos \omega_1 t \qquad (t = 0 \text{ for } \Delta f_{max})$$

$$\Delta f = f_m \phi \qquad (3)$$

where $\omega_1 = 2\pi f_m$
$f_m$ = modulating frequency
$\phi$ = angle in radians

### Circuit Operation

A simple circuit for performing this type of modulation fundamentally is shown in Fig. 1. Elements $C_1$ and $L_1$ are the crystal-oscillator plate-tank components adjusted for oscillation in the usual way. The circuit $L_2C_2$, inductively coupled to the oscillator tank, is adjusted so that it acts capacitively. For example, if the phase shift produced by $C_1$ and $L_1$ while loaded with $C_2R_1$ and the distributed input values of Mod No. 1 could be made plus 45 degrees, and that from $L_2C_2$ in turn made minus 45 degrees by detuning for higher inductance, then the potential on Mod No. 1 would be 90 degrees out of phase with respect to that of Mod No. 2 (Fig. 1). Now if these tubes (12SA7's) are differentially (push-pull) amplitude modulated at their No. 3 grids by an a-f input indicated so that the r-f in the No. 1 grids can be used in inverse degrees, $C_eL_s$ will alternately be driven with the r-f component from the grid of one of the 12SA7 modulators and then the other. During one-half of an audio cycle, the utility of the r-f energy in the modulator grid circuits will be transferred from one 12SA7 to the other and 90 degrees of r-f phase will be gained or lost depending on the instantaneous polarity of the a-f. The modulation process will bring about a smooth transition of energy from one source to the other.

The mechanism of this type of modulation is shown in Fig. 2. The designation $e_1$ refers to the carrier component entering the grid of Mod No. 1 (12SA7) of Fig. 1 and $e_2$ is the wave entering the other

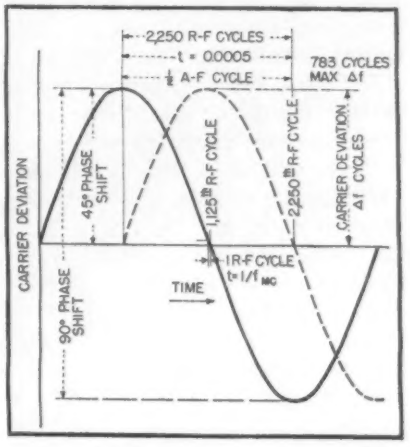



**FIG. 3—Determination of frequency deviation produced by modulator**

12SA7 modulator grid. Each cycle of $e_1$ is marked off and its period $T_1$ is constant. Likewise $e_2$ has a constant period $T_2$ and throughout the entire range of $e_2$ it is lagging $e_1$ by exactly 90 degrees.

Now $e_1$ is decreasing in amplitude due to amplitude modulation, while $e_2$ is increasing in amplitude. The sum of these two waves is designated $e_3$. This sum-wave (dotted curve Fig. 2) appears in $C_3L_3$ of Fig. 1. Note in Fig. 2 that as the amplitudes of $e_1$ and $e_2$ change inversely the sum-wave $e_3$ is actually changing frequency. Its frequency is lowered by the ratio of $(\Delta T_1 + T_1)$ to $T_1$. It appears to be changing phase with respect to $e_1$. If this process can be made to take place fast enough, a considerable frequency change can be brought about. To understand how a phase shift amounting to a fraction of an r-f cycle can bring about many hundreds or even thousands of cycles deviation, it is important to note carefully that only one-half of one a-f cycle from positive to negative peak is shown in Fig. 2.

### Frequency Deviation

We must produce all of the r-f frequency change or deviation from the carrier in the time consumed by one-half of an a-f cycle just as we must achieve all of the amplitude change from peak to peak of the a-f cycle in this time. An example of the conditions actually used may serve even better to explain the phase modulation.

With a carrier of 4.5 mc and an a-f of 1,000 cycles, in 1/2000th second we must obtain 90 degrees of phase shift between the two carrier components derived from the oscillator. In this time there will occur 4,500,000/2,000 or 2,250 r-f cycles. At the middle or 1,125th r-f cycle the maximum deviation will occur.

There will be 45 degrees r-f phase shift at the middle cycle covering 90 degrees of the a-f cycle. Thus the maximum phase shift per r-f cycle to quite a high degree of accuracy will be

$$\Delta_f = 45 \sin (90/1125)^\circ$$
$$= 45 \sin 0.08^\circ$$
$$= 0.06264^\circ$$

Figure 3 shows the conditions involved here. Because these values are given in degrees, it is obvious that if the time of one cycle is measured by 360 degrees that the time of this cycle in question is longer by 0.06264 degrees and the ratio of 360 to 360.06264 is 1.0 to 1.000174. Multiplying 4.5 mc by this figure we obtain 4.500783 mc showing that the carrier has deviated 783 cycles from 4.5 mc. From Eq. 3 it is clear that the deviation is proportional to the a-f times the total angle of phase modulation. For example with 1,000 cycles a-f and a total phase shift of 90 degrees or $\pi/2$ radians, from Eq. 3 we have $1{,}000\pi/2$ or 1,566 cycles total deviation of which 783 cycles or one-half of this is the deviation in one direction from the carrier. Thus by this process of rapidly shifting phase, it is possible to change the frequency considerably.

The method of modulation of the 12SA7 modulators from the amplitude viewpoint in Fig. 1, is not important except that it must be as linear as possible and as near 100 percent as possible if the advantages of total phase shift are to be realized. Grid modulation using converter tubes such as the 12SA7's shown in Fig. 1 provides a good means although 100-percent modulation may not always be realized. Plate modulation would seem effective although more apparatus is required and the circuit is thereby made more complex.

Because the r-f phase-shift rate and hence the deviation of the carrier is dependent upon the a-f, the degree of modulation must be made inversely proportional to the a-f if a constant bandwidth is desired. A network for accomplishing this was found unnecessary however and was not used. Because the transient noise components are largest in the upper part of the a-f band the modulation factor (ratio of carrier deviation to a-f) being constant, the noise will be attenuated more than it otherwise would be. Audio correction can be made easily in the a-f system of the receiver.

### Practical Circuit

Although the circuit of Fig. 1 is useful for explanation it is not a practical circuit. Adjustment of the phase-splitting circuit $L_2C_2$ would affect the operation of the oscillator. Every time the oscillator is adjusted, the phase between the grids of the 12SA7 modulators is altered. Out of several circuits tried, a final design was chosen. It is shown in Fig. 4. In this circuit, the oscillator may have any phase suitable for oscillator tank components $C_1$ and $L_1$.

Using the output voltage at $C_2$ as a reference, components are fed through resistors $R_1$ and $R_2$ to two individual tank circuits $L_2C_3$ and $L_3C_4$. The shunt impedances of these tank circuits unloaded are approximately 80,000 ohms at resonance

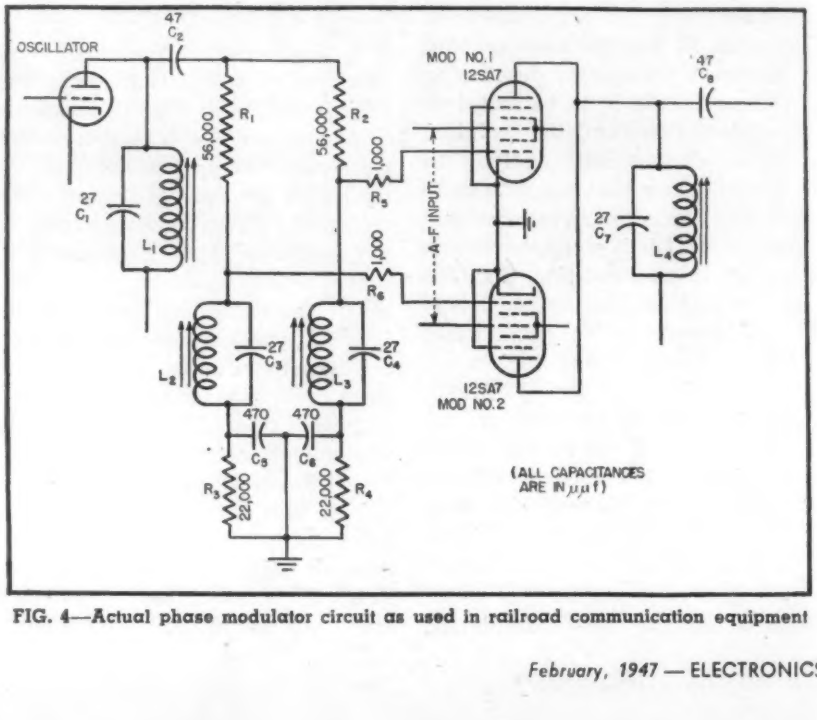



FIG. 4—Actual phase modulator circuit as used in railroad communication equipment

and they lose about 30 percent of this value when displaced 45 degrees in phase by tuning. Values of $R_1$ and $R_2$ up to 560,000 ohms were found quite successful, but lower values made adjustment of $L_2$ and $L_3$ less critical and suitable for a fair degree of oscillator frequency range without readjustment. In addition, the grid driving voltages into the phase modulators were increased to a more practical degree through a more favorable voltage division between the series resistors $R_1$ and $R_2$ and the tuned circuits.

The grid drive must be just adequate to produce a vector sum in the plate circuit $C_7L_4$ sufficient to drive the following tube. More than this amount of drive makes grid modulation less effective in the limited grid range for a-f. Values of 56,000 ohms for $R_1$ and $R_2$ were found satisfactory. Capacitors $C_3$ and $C_4$ are large enough (27 $\mu\mu$f) so that the modulator tubes can be replaced without readjustment of $L_2$ and $L_3$ and to provide ready compensation for distributed capacitances. Bias and bypass components are conventional.

Because the driving power was more than enough for the purpose, it was found more practical to use grid or plate suppression of self-oscillation than any form of neutralization. Grid suppressors $R_5$ and $R_6$ are shown in Fig. 4 and are adequate for the purpose. Inductors $L_2$ and $L_3$ can be adjusted with an oscilloscope and set for the life of the equipment. They are set at the r-f grids of the phase modulators for the most perfect circle obtainable (showing 90 degrees phase difference between the r-f components fed to the grids). Phase modulation can be observed and the actual angle of modulation measured by attaching the vertical and horizontal free oscilloscope plates to $C_2$ and $C_8$, and adjusting $L_4$ for a straight diagonal line in the absence of modulation. Modulation will open the line into a family of ellipses the limits of which will be an index of the angle of phase modulation. Ninety degrees phase modulation will be indicated when the major axes of these ellipses are four times the lengths of their minor axes and their major axes are 45 degrees from each other in their limiting positions.

### Linearity Calculations

The oscillator frequency was arranged to be multiplied 36 times to the vhf output of 152 to 162 mc to take advantage of the phase modulator and have a deviation of approximately 30-kc total at the carrier output. For overall modulation angles in the neighborhood of a radian, the overall distortion was found to be about 9.5 percent so the following calculations were made to determine the distortion inherent in the phase modulator for 90 degrees total phase shift (approximately 1.5 radians).

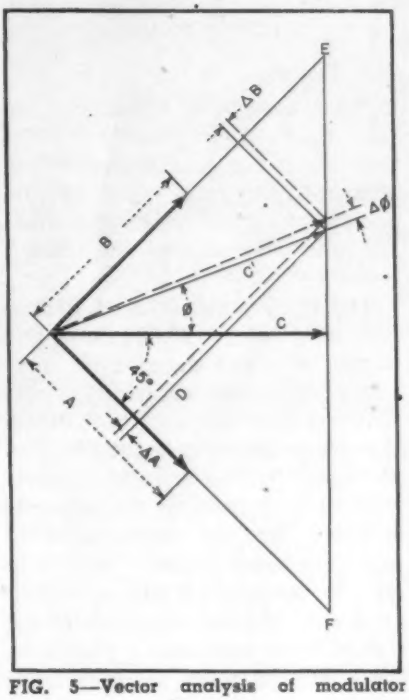



FIG. 5—Vector analysis of modulator linearity

Figure 5 shows vector grid components $A$ and $B$ 90 degrees displaced, and a sum vector $C$. Linear amplitude modulation of $A$ and $B$ will subtract an increment $\Delta A$ from the $A$ vector and add an equal increment $\Delta B$ to the $B$ vector at any arbitrary point in the a-f cycle simply by definition of linear modulation. These increments will produce a phase shift $\Delta\phi$ of the sum vector. Line $EF$ is the locus of all positions of the sum vector $C$ limit, and by geometry, any increment such as $\Delta A$ will intersect proportional increments along $EF$. The angle $\Delta\phi$ however, will vary throughout the distance $EF$. From Figure 5, it may be seen that

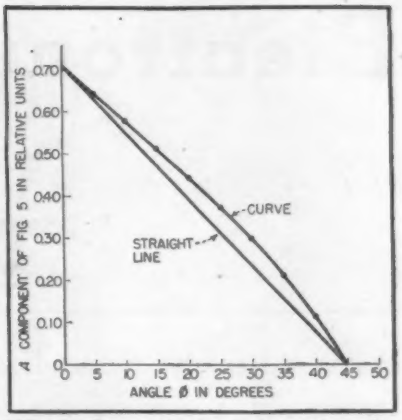



FIG. 6—Curve shows degree of nonlinearity in modulator circuit

$$\frac{C}{C'} = \cos\phi \tag{5}$$

and $\frac{A}{C'} = \cos(\phi + 45°)$

or $A = C'\cos(\phi + 45°)$ (6)

Substituting Eq. 5 in Eq. 6

$$A = \frac{C\cos(\phi + 45°)}{\cos\phi} \tag{7}$$

Equation 7 gives us a true expression of $A$ in terms of $\phi$ and constants. Plotting $A$ in relative units against $\phi$ (C=1) between zero and 45 degrees for $\phi$, we obtain the curve shown in Fig. 6. This curve shows that within 90 degrees total phase shift the proportionality between $A$ and $\phi$ is fairly good. The distortion resulting from this much curvature is directly related to the area between the curve and the straight line as compared to the total area under the curve. This was roughly estimated at 9 percent which checks well with actual measurement. At the low-level point where phase modulation is accomplished other sources of distortion are very low, less than one percent by measurement.

It is interesting to note that if modulation makes $A$ or $B$ of Fig. 5 more than double, the phase change abruptly stops. An analysis was made on this same basis of the distortion conditions for a total phase shift of 120 degrees and the distortion was estimated at about 43 percent which is, of course, prohibitive for intelligibility using ordinary communication techniques.

# Electronics in the CATERPILLAR TRACTOR PLANT

**Personnel safety, reduced maintenance costs, improved quality and increased production tempo are a few of the advantages for a manufacturer using electronic methods intelligently**

**ELECTRONIC DEVICES**

Coil-Winding Speed and Direction Control
Crankshaft Finish Grinder Control
Induction Heater (brazing)
Magnetic Chuck (rotary table grinder)
Annealing Oven Feed and Discharge Control
Flame-Failure Protection Devices
Multiple Temperature Recorders
Fuel Proportioning Control
Intercommunicators
Diathermy (infirmary)
Automatic Welder Controls (track rollers)
Seam Welder Controls (fuel tanks)
Nonoxidizing Welder Controls (seams)
Crankshaft Balancer
Mass Spectrograph
Spectrum Analyzer
Microphotographic Controls
Power-Factor Corrector
Air-Cleaner
Safety Device for Spectrometer
Cathode-Ray Oscilloscopes
Oscilloscope Preamplifiers
Cathode-Ray Tachometer
Oscilloscope-Trace Time Marker
D-C Amplifier
Continuous-Graph Ink Recorder
Torsion Tester for Crankshafts
Synchronous Sweep Generator
Photoelectric Timing Mark Generator
High-speed Cameras
Stroboscopes
Strain Indicators
String Oscillograph
Oscillator
Frequency Meter
Sound Analyzer
Vibration Analyzer
Sound Level Meter
Safety Device for Hydraulic Press
Sequence Timer for Machine Operation
Moisture Meter (lumber)
Surface-Roughness Tester
Comparator Gage
Insulation Tester
Tube Tester
Voltage Regulator

THE Caterpillar Tractor Company manufactures Diesel tractors, motor graders, bulldozers, scrapers and other earth-moving equipment as well as Diesel engines for industrial, marine and electric power use.

The main plant, in East Peoria, Illinois, employs 20,000 men and women who are engaged in every phase of a manufacturing process that turns raw metals into thundering prime movers. About 550 people work in the research department, 475 of them on the grounds occupied by the manufacturing plant but apart from it physically and in purpose. While a certain amount of life testing is carried on, the principal emphasis is placed on the purely research aspects of developing better Diesel engines and associated equipment,—gears, crankshafts, and bearings that are necessary to improve the product.

### Electronic Methods

In common with other progressive but practical industries, this company has little interest in electronic devices as such, but uses electronics whenever the technique does a job better or cheaper than other methods.

In the factory, many packaged units of conventional manufacture are permanently installed as a regular part of the production line machinery. In addition, a number of other devices, manufactured by the maintenance department from parts at hand are in regular daily use.

The research department, although using a large number of packaged electronic units, is, by the nature of its work, likely to rig up temporary combinations of equipment, some purchased, some fabricated in the laboratory, in such a manner as will serve a given short-term experiment to best advantage. To this end, a regular cataloged stock is maintained consisting of resistors, capacitors and meters, and over 75 different tube types.

Although many of the research engineers and physicists encounter no difficulty in developing and using electronic testing techniques, it has been thought advisable to add to the staff a full-time electronics engineer who is available for consultation with other members and designs new testing equipment for more exacting research.

### Temperature Controls

For temperature recording and control of heat-treating processes there is no substitute for electronic means that will maintain temper-

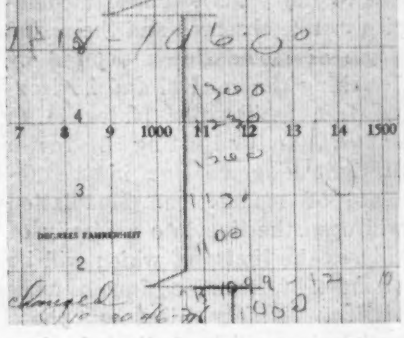



**FIG. 1—Portion of temperature graph from a heat-control unit. For this particular application, a variation of 4 degrees each side of 1060 is tolerated when the oven has come up to temperature**

**Airplane view of the East Peoria plant of the Caterpillar Tractor Company. The business section of Peoria is seen across the Illinois River**

ature within the required narrow limits.

A large number of drawing furnaces in the plant require different types and degree of control together with a continuous graph of temperature. Packaged units manufactured by two different companies are used, although some of these have been modified in the plant. All these equipments operate on variations of the bridge principle wherein unbalance is indicated by a pen or stylus making a lateral movement of its trace on a vertically moving continuous strip of graph paper such as that shown in Fig. 1. This same deviation from a balance point, corresponding to a desired temperature, can be translated into countermotion of a fuel valve to maintain the temperature within either a few degrees or even within a fraction of a degree. Earlier models of commercial equipment have been modified so that a single recording and control mechanism can be switched from one oven to another. Each trace is then made up of a series of dots and dashes with a means of identifying the different traces. Later commercial equipment for multiple control prints the trace number in small but legible characters beside each point. Motorized positioning controls connected to the recorder through a selector switch adjust the flow of gas.

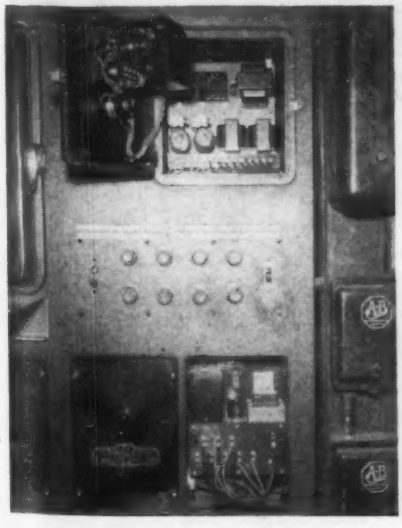


**FIG. 2—Continuous temperature control associated with graphical recorder is shown at top. Lower section of draw-furnace panel carries electronic flame control safety equipment**

### Flame Failure Protection

Another important consideration in heating equipment using gas is the danger of flame failure. If it were extinguished even momentarily and the flow of heating gas continued, an explosion might occur that would injure personnel and damage equipment.

Such an untoward event is effectively guarded against by a combination of controls. A pilot flame in the oven is kept burning at all times so that no appreciable amount of unburned gas can accumulate. In addition, conductivity through the pilot flame maintains a negative bias on the grid of an electronic control tube, connected to an emergency gas shutoff valve. If the pilot flame fails for an instant, the bias is removed from the tube, current flows through a relay in the plate circuit, and gas flow stops. It can not be restored until the heating

FIG. 3—Discharge end of heat-treating oven with material emerging. Photoelectric devices open oven doors and speed rollers as charge nears end of journey. At the same time, doors at the other end open to receive a new charge

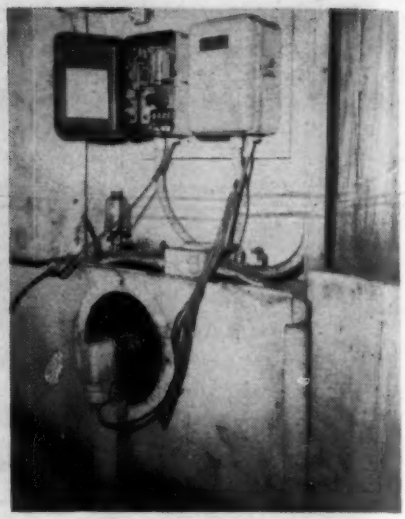


FIG. 4—Phtotube electronic control equipment used in opening and closing doors of heat-treating oven

apparatus is recycled by relighting the pilot and biasing the flame control tube. Packaged units are shown in Fig. 2.

### Continuous Drawing Oven

By extension of the electronic techniques for control and safety, it has been found practicable to build a drawing oven for heat treating that requires only the racking up of material at one end as it comes from one manufacturing process and lifting it off at the other with a compressed air hoist, as shown in Fig. 3, as it emerges. All intermediate steps are cared for by electronic controls.

The oven is 100 feet long and is kept at a temperature such that the material moving through at a specified rate receives the proper treatment. Transit is accomplished by mounting the material on rails or bars that move easily across revolving rollers. As the rails reach the far end of the oven they interrupt a beam of light that is sent from a lamp at one side of the oven through a window to a phototube at the opposite side as illustrated in Fig. 4. Relays and contactors then set into motion the machinery for raising the guillotine doors at both the charge and discharge ends of the oven. At the same time, the apertures are screened by a gas reducing flame that prevents an undue amount of oxygen from entering, and the last few rollers at both ends are speeded up so that the material is discharged quickly onto an undriven-roller platform. As the new charge passes the opening at the incoming end, a light beam at that end is broken, the gas flame is reduced to a minimum and the guillotine door closes. Since the action is automatic, the process requires only relatively skilled operators at each end to charge and discharge the oven.

### Welding Controls

A number of production welding operations in the plant require specialized equipment. Among these are a commercial seam welder for fabricating fuel tanks. Two tanks at a time are handled by this machine in which the previously formed sides are butted together and clamped in proper position on the welder. The operator throws a switch and fluxed welding rod is unreeled at a proper speed, arc current is maintained at the proper value and the welding rod carriage moves along at a speed that is also determined electronically.

Another type of straight-line welder, shown in Fig. 5, is less formidable in size and works in

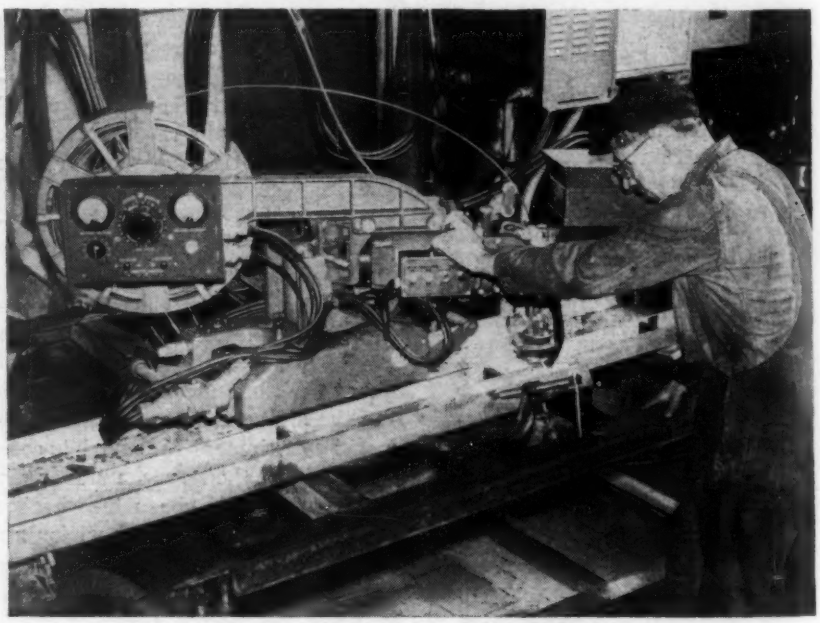


FIG. 5—Seam welder controls are mounted on carriage and connected by cable with electronic equipment in box over operator's head

such a way that it minimizes oxidation. A small unit moves along a track with the power and electronic controls connected to it by cable. Meters and control switches are mounted on the carriage. A hopper filled with flux and a blanketing material resembling sand maintains a flow to cover the arc at all times. The proper proportioning of current, speed of movement and welding-rod feed is electronically maintained.

Still another type of welder is used for joining the hubs of two flanges together to form the rollers used in carrying the tracks of diesel tractors. A three-position revolving jig is arranged so that while one roller is being welded another is in position for heating by a gas flame and the third position of the jig is available for a new pair of flanges to be affixed. Each position rotates continuously. In the welding position, electronic controls apportion the proper current while fluxed rod is fed down from a large reel overhead that contains an 8-hour supply.

### Safety Devices

Electronic controls are used as safety devices to prevent the operation of equipment during periods when material is being introduced or when preliminary adjustments are made. Two examples of this technique are given below.

A hydraulic press illustrated in Fig. 6 is controlled by two switches so that the operator must theoretically operate a switch with each hand in order to start the machine. However, since it is not impossible to operate the switches by means of a hand and an elbow, a photoelectric device has been added to give a maximum of protection. It consists of a light beam that must be unbroken before power can be turned on. In the photograph, the light beam entering the invisible maze from the left is reflected four times, making a total of five paths that must remain unbroken before the punch can be operated and which will instantly stop the punch if broken. The four mirrors shown have since been replaced by two mirror strips, one on each side of the operating position, so that an extremely intricate maze is developed by multiple reflections between the mirrors.

Another unique instance of personnel protection is a metal-mesh screen placed above the sparking section of a mass spectrograph used in the analysis of metals. Because of the high potentials involved in producing the spark it is extremely desirable to afford the operator a measure of protection. A black box contains electron-tube circuits such that a change of capacitance in the grid circuit of the first tube initiates an impulse that is amplified in following tubes to cut off high voltage from the semi-exposed terminals. The mesh screen serves as one plate of a capacitor, the spectrograph serves as the other, and the operator's body acts as a change in the dielectric, throwing the capacitance to another value. So long as he is near the equipment the operator can not turn it on.

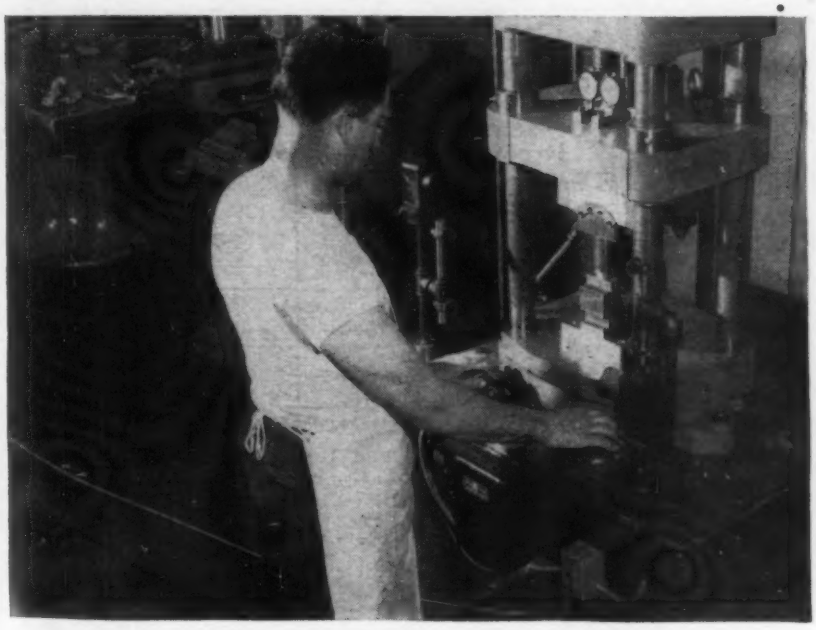


FIG. 6—Hydraulic press protective device. The equipment stops if the light beam reflected back and forth by four mirrors between source and phototube is broken

FIG. 7—Complete control equipment for crankshaft grinder. Vacuum-tube section occupies left-hand bay

### Crankshaft Finishing

An otherwise difficult operation of finishing crankshafts and balancing them has been eased by electronic circuits. The finish grinding is done on a commercial machine in which the grinding wheel is driven by an a-c motor but the crankshaft itself is revolved at the required speed by an electronically controlled d-c motor. The control equipment pictured in Fig. 7 uses 14 tubes about equally divided between the so-called industrial and communications types.

After the grinding process, each crankshaft is balanced in a machine designed to indicate by means of simple dial readings the crankshaft angle at which unbalance occurs and the amount of unbalance at this point. The equipment is operated from a-c but the shaft is rotated by means of a d-c motor. Four industrial type tubes are used to operate the motor directly, but eight communications types handle the off-balance indication. By means of this versatile and accurate ma-

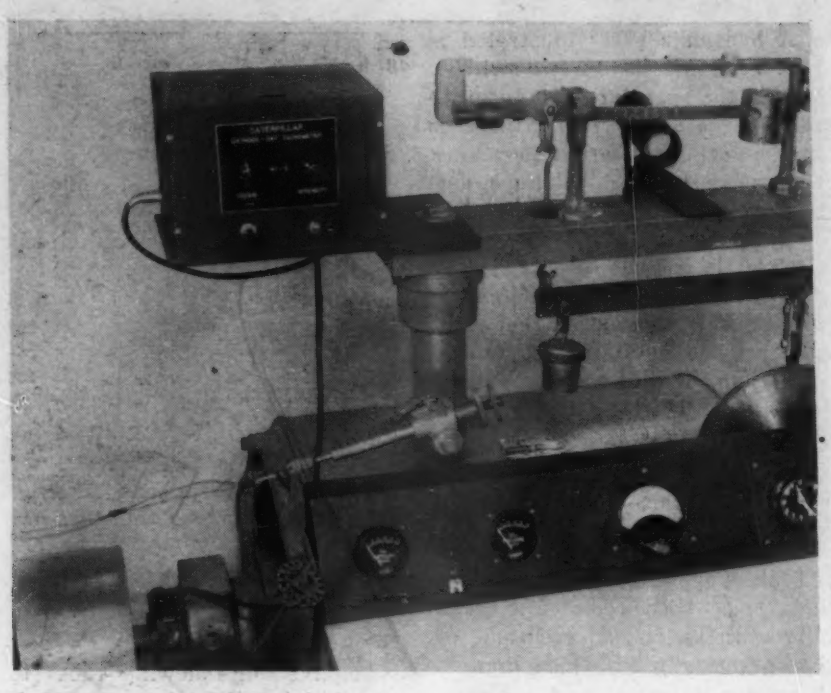


FIG. 8—Cathode-ray tachometer. Pickup and cam mounted on shaft of dynamometer at lower left. The viewing tube at the upper right can be swiveled into almost any position

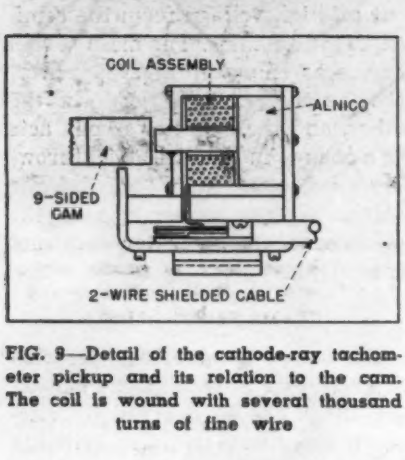



FIG. 9—Detail of the cathode-ray tachometer pickup and its relation to the cam. The coil is wound with several thousand turns of fine wire

chine, a skilled machinist is able quickly to check a crankshaft, remove it to a drill press nearby, drill out a small amount of metal from the appropriate point to obtain balance, return the crankshaft to the balancing machine and recheck it under the changed conditions.

### Cathode-Ray Tachometer

A typical laboratory device is the cathode-ray tachometer used in maintaining constant engine speed under test conditions. It is frequently desirable to obtain data on the performance of new engine parts or techniques which, if continued many minutes would result in the destruction of equipment. Ordinary mechanical tachometric devices often lack the necessary long-term accuracy and in any case require an appreciable time of observation in order to integrate slight speed variations.

The cathode-ray tachometer to be described is limited in the number of definite speeds it can accurately indicate, but gains in simplicity and suffices for all practical purposes. A small metal cabinet shown in Fig. 8 and containing only intensity and focus controls is bolted to the standard dynamometer test bench, out of the way but accessible. The 2-inch cathode-ray indicator tube is mounted in a ball-and-socket joint so that it can be swiveled into any position convenient for observation by either the operator at the test bench or an assistant working on the other side of the engine. The pickup illustrated in Fig. 9 is mounted near the dynamometer bearing housing close to a 9-sided cam attached to the shaft. Two pole pieces at right angles to each other, one near the periphery of the cam and the other near the side form a closed magnetic circuit, the flux density of which is affected by rotation of the cam. Output from the pickup is fed through a 2-wire shielded microphone cable to the amplifier.

Placement of the pickup is not critical. The overall gain of the system is adequate to permit speed measurements on tiny motors using the slight nonuniformity of the

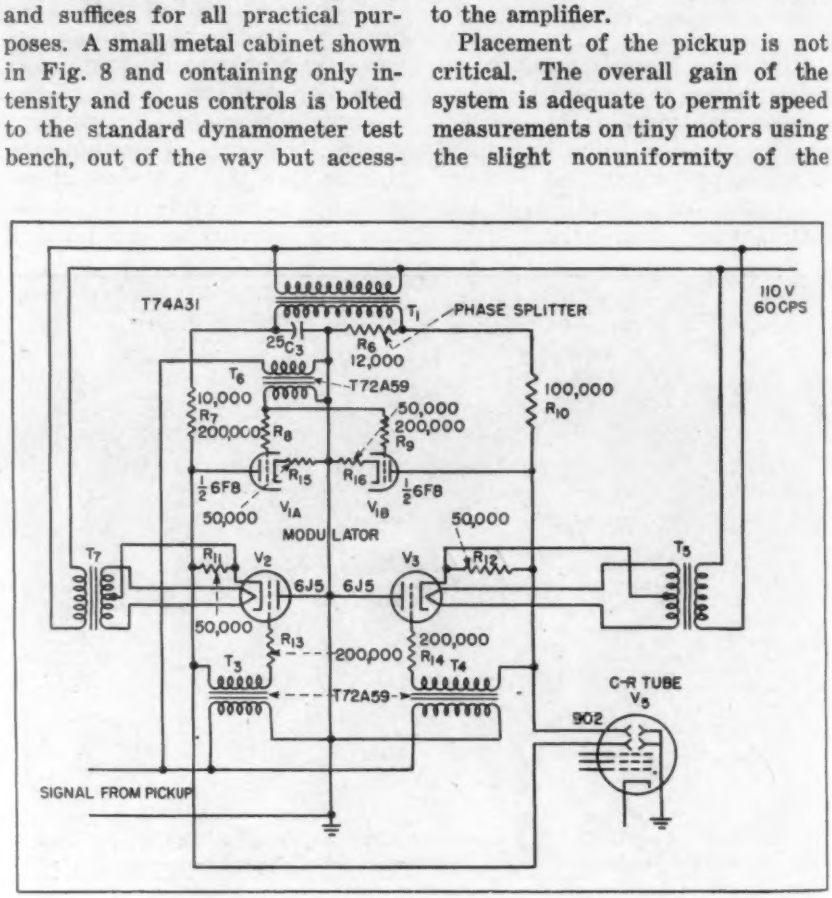



FIG. 10—Schematic circuit diagram of the cathode-ray tachometer

shaft, owing to flattening or a keyway, as the variable element in the magnetic circuit.

Making use of the fact that the 60-cps power line frequency is controlled to very close limits, the electronic circuits of Fig. 10 provide a circular pattern on the oscilloscope resulting from the phase-splitting circuit $C_3$, $R_6$ across the secondary of step-up transformer $T_1$. The approximate sine wave generated in the pickup is simultaneously coupled through transformers $T_6$, $T_5$ and $T_4$ into $V_1$, $V_2$ and $V_3$ in such a way that at the same instant $V_{1A}$ and $V_3$ are conducting, whereas on the next half cycle, $V_{1B}$ and $V_2$ conduct.

Since conduction through the tubes results in a decrease in voltage fed to the deflection plates of the cathode-ray tube and since the action occurs in a way to reduce the voltage on opposite plates at the same instant, the static circular pattern is modulated into a form containing one or more petals, or bumps. The shape of the bump is not critical and depends to a great extent upon the form of the cam inducing the pickup voltage. Since the line voltage corresponds to 3,600 rpm and the cam has 9 faces, each bump on the circular trace indicates a speed of 400 rpm, or with a 2-line pattern each bump represents 200 rpm.

Highest speed that can be easily read on the present equipment is 2,400 rpm (12 bumps), adequate for relatively slow-speed Diesel engines. Speeds intermediate between the 200-rpm increments are indicated qualitatively by a revolution of the notched trace. While it is seldom necessary to run at intermediate speeds, the ordinary tachometric equipment can then be used with 200-rpm points calibrated against the electronic tachometer.

In one test, the position of a fuel-pump plunger is accurately measured by a micrometer. The test operator checks the position by screwing the micrometer in until fuel begins to be reduced. This slowing down because of reducing fuel is immediately apparent using the cathode-ray tachometer and the operator can quickly back off the micrometer without sensibly affecting the test.

### Dual-Gun Oscilloscope

Electronic techniques are mandatory for economical and accurate recording of data involving simultaneous observation of several phenomena. The dual gun oscilloscope and associated amplifiers illustrated are used in a fuel testing setup in which photographic recordings are made of pressure, fuel injection needle motion, flame intensity, and the pressure of nitrogen fed into the precombustion chamber of a Diesel engine. The interconnections are shown in Fig. 11.

A visual indication is given showing the position of the flywheel at the same instant that a mark is placed on the photographic record. The significant portion of the record is initiated by means of a crankshaft commutator that flashes a light to indicate the position of the engine shaft. This flash is picked up by a phototube and fed into an input of a four-channel mixer. The mixer and its power supply are shown between the amplifiers on the lower deck of the equipment dolly in Fig. 12. Pressures and fuel valve needle position are continuously photographed. Other varying functions like flame intensity are observed by a second phototube. Signals are fed through appropriate amplifiers into the modified oscilloscopes and then into the double-gun tube. A representative record showing only two elements and a single shaft-angle mark is illustrated in Fig. 13.

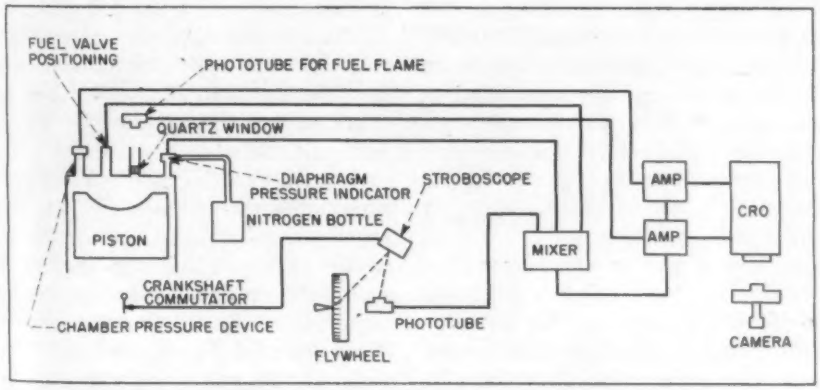



FIG. 11—Block diagram showing electronic equipment setup for engine test. Fuel-valve position is converted to a variable voltage as is diaphragm pressure. Fuel flame is viewed by a phototube. A high-speed camera photographs the traces on the dual-gun oscilloscope

FIG. 12 — Dual-gun cathode-ray oscilloscope, with two amplifiers and marker mixer on lower shelf

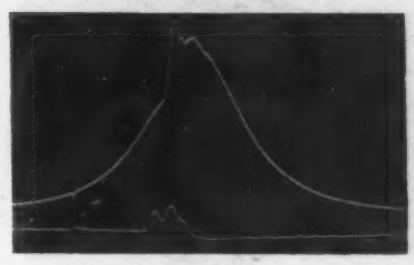


FIG. 13—Pressure curve from diesel engine precombustion chamber is shown on upper trace, with fuel injection needle motion shown below. A single shaft-angle mark appears on both traces


### Acknowledgment

The assistance of E. W. Landen, Gordon Monfort, Jerry Reichart, C. R. Schad, S. J. Schmidt and George Walters in the collection and review of the material from which this article has been written is gratefully acknowledged.

—A.A.McK.

# Supply for EQUIPMENT

**Continuously variable from 300 to 5,000 volts, the voltage-regulated power supply described utilizes an electronically controlled servo motor to automatically adjust an auto-transformer. The d-c output of the device has less than three millivolts ripple at all voltages**

Then the contacts of both relays are open and the motor is not operating. As the regulator-tube voltage becomes lower, the $V_2$ bias becomes less negative, and this tube conducts, energizing the RAISE relay. The bias of $V_1$ is also decreased, but since $V_1$ was already conducting, the change has no affect on the LOWER relay. Thus, the motor operates to restore the regulator-tube voltage, until the restored voltage cuts off $V_2$.

When the regulator-tube voltage becomes too high, the increased $V_1$ bias cuts off tube $V_1$. This de-energizes the LOWER relay, thereby closing its contacts to operate the motor to lower the voltage to normal.

The normal voltage bandwidth can be adjusted by $R_2$. Its centerpoint is set by $R_3$. This servo control is necessarily a discontinuous type[2] because a primary voltage correction should be made only when the regulator tube is getting too near the limit of its ability. Narrower bandwidth is not desirable.

Before power is applied to the transformer, or before the 6SN7GT is warm, the relays are in a position to lower the autotransformer. The failure of either the 6SN7GT or the 5Y3GT tube would result in a lowering of the transformer primary to zero. Thus this control circuit is inherently safe. This servo-transformer arrangement can be made to work with existing regulator circuits as well as with the one described.

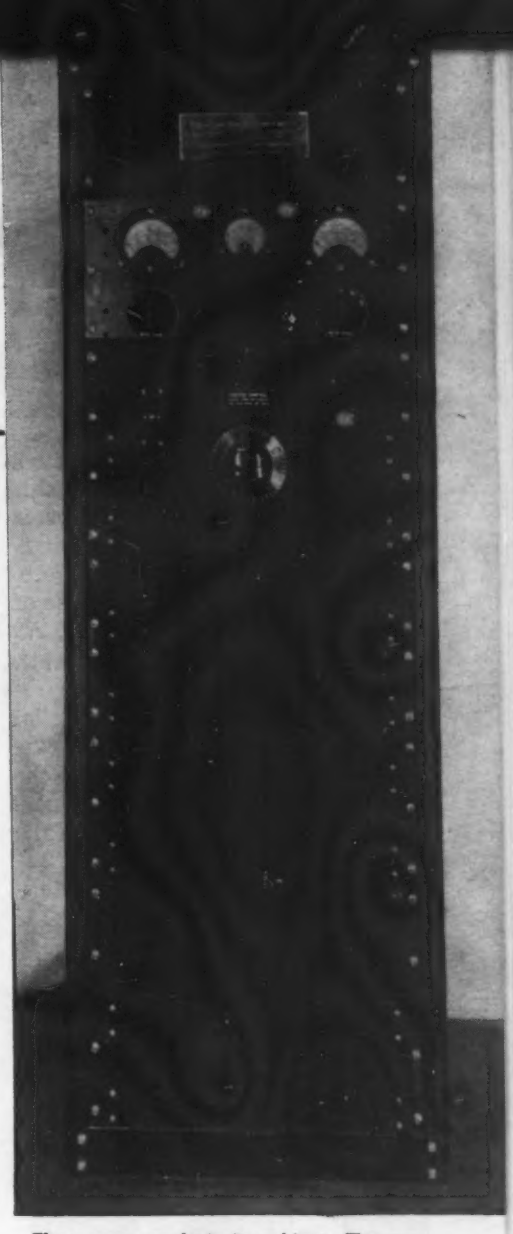
### Rectifier and Filter

The rectifier of Fig. 1 is a conventional six-phase single-Y circuit with delta primary. The primary is rated at 208 volts, 60 cycles. The filter requires some special consideration because neither the positive nor the negative lead is grounded. Instead, the positive output after the regulator must be grounded in most microwave work. Since the positive output is not common with any lead in the filter, the latter must float with respect to the ground. This would interfere with the filtering action and produce spikes too large to be corrected by ordinary regulator tubes. Figure 3 shows how the filter is bypassed in a way to eliminate the spikes caused by the distributed capacitances in the transformer. High alternating voltages are bypassed to ground through each 0.1 $\mu$f capacitor.

### Regulator Circuit

The circuit of Fig. 4 shows an inverse-feedback regulator with some fundamental changes. To eliminate the long string of voltage-regulator tubes employed in older regulators, an independent regulated auxiliary voltage source is used. This serves two purposes; first, it supplies the reference voltage and it is extremely stable and constant; second, it is a constant plate supply for the regulator's direct-coupled amplifier.

The reference voltage is compared in the right-hand section of the 6SL7GT to that appearing across $R_1$. The difference is the signal which, when greatly amplified, drives the 6B4G regulator tubes. The auxiliary voltage source is constant for all output voltages.



**The power supply in its cabinet. The master control provides both coarse and fine adjustment by taking advantage of the slack in the gear train**

When the regulator is operating at high voltages, $R_2 = 12 \times R_1$ and the magnitude of the d-c signal is reduced by the factor $R_1/R_1 + R_2$ or 1/13. At lower output voltages, this factor approaches unity. Actually, however, the gain of the amplifier (estimated to be greater than 15,000) is so large that this voltage division becomes negligible. Furthermore, the capacitor $C_1$ increases the factor to nearly unity for rapid changes in the divider by effectively shunting $R_2$.

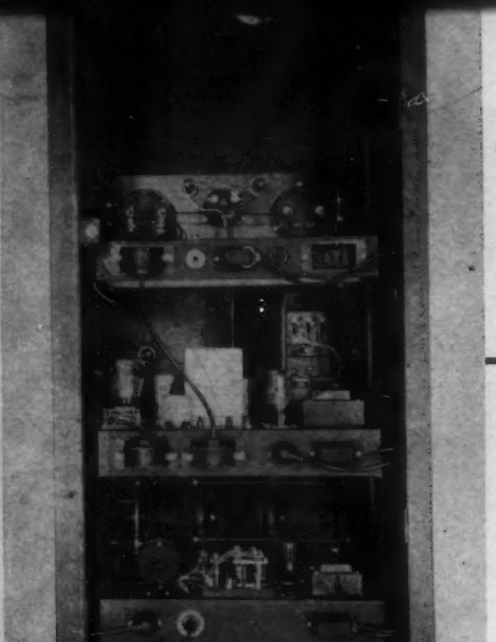
Because of the high gain, the regulator has a strong tendency to oscillate, but the addition of capacitor $C_2$ across the output prevents the overcompensation caused by the high gain. The stabilization ratio is defined as $dE_i/dE_o$ where $E_i$ is the voltage applied to the regulator and $E_o$

# Power S

# MICROWAVE E

By OLIVER HOAG

*Project Engineer*
*Research Laboratories*
*Sperry Gyroscope Co., Inc.*
*Garden City, N. Y.*



**Chassis of the high-voltage power supply. From the top down: meter panel, regulator and control panel, servo transformer, filter, and rectifier**

DUE to recent trends toward high frequencies, power supply requirements have become more stringent. In microwave equipment, operating voltages must be extremely stable to maintain necessary frequency stability. This is particularly true in the case of laboratory equipment.

The requirements for an adequate voltage supply in the laboratory operation of the majority of microwave tubes are:

(1) It should have excellent regulation for line voltage fluctuation, less than five millivolts of ripple, and efficient control for load current fluctuation.

(2) The output voltage should be smoothly variable without steps through the entire voltage range.

(3) Operation should be convenient and simple, with a minimum number of controls.

(4) The supply should be fully protected for the safety of the operator and of the tube under test.

(5) To be useful for medium and high-power tubes, voltage and current range should be wide.

### Present Circuits

The common inverse-feedback regulator circuit can be designed to give the required regulation at low voltages. However, at higher voltages more glow-discharge, voltage-regulator tubes for the reference voltage are necessary. For an output of 5,000 volts, approximately 31 type OD3/VR150 tubes would be needed. Furthermore, most voltage-regulator tubes have small spasmodic variations in the order of 0.1 to 0.5 volt.[1] Because even the finest voltage-regulator tubes have some spasmodic variations, the chance of a voltage shift is multiplied by the number of voltage-regulator tubes in the string, and any changes that do occur will appear in the output. Such disturbances can be observed in the output of all high-voltage regulators, and can usually be traced to the VR tubes.

Conventional low-voltage regulator circuits usually include some kind of compensation for input voltage variations but satisfactory compensation is not possible when the number of VR tubes in the circuit is changed frequently.

Another objection to a power supply using many VR tubes is the number of controls necessary for its operation. Three adjustments must be made for each voltage setting; a coarse tap-switch control, a transformer primary voltage adjustment to put the correct voltage across the regulator tube, and a fine control setting.

### Automatic System

This paper describes a voltage regulator system of four main parts, meeting all five requirements of a high-voltage supply for laboratory use. The output is smoothly and continuously variable from 300 to 5,000 volts or higher, using one knob.

While designed for laboratory use on microwave oscillators and amplifiers, the characteristics of this regulated supply are such that it should prove useful for many other applications requiring high voltages with good flexibility and regulation, provided the positive output can be grounded.

### Control Circuit

The block diagram in Fig. 1 shows the four essential units. The servo-transformer unit consists of a three-phase autotransformer to vary the primary voltage of the high-voltage transformer (and thus the d-c input of the electronic regulator), a reversible servo motor geared to the autotransformer, and a control circuit.

The operation of the control circuit can be seen by reference to Fig. 2. The regulator-tube voltage appears across the divider $R_1$, $R_2$, $R_3$. The voltage appearing across $R_1$ is compared with the independent plate supply and the difference is the bias for $V_1$, the left-hand section of the double triode. Similarly, the difference between the voltage appearing across $R_1 + R_2$ and the plate supply is the bias for $V_2$, at the right. The value of this voltage is greater than that applied to $V_1$.

With normal regulator-tube voltage, $V_1$ conducts and $V_2$ does not.

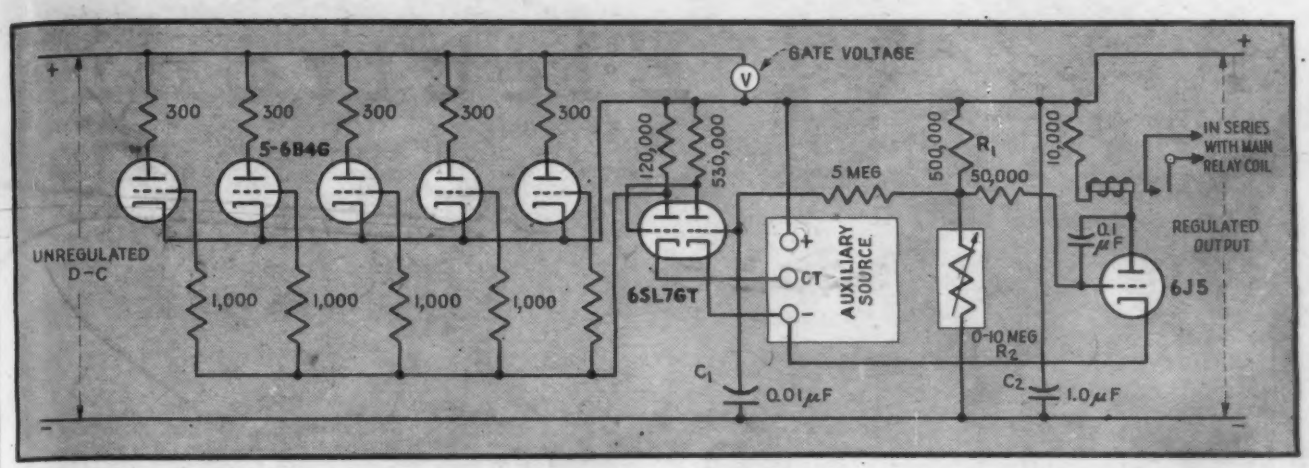



FIG. 4—Inverse-feedback type of regulator with auxiliary voltage source to supply the reference voltage

increase to an excessive value. Regulator tubes, and perhaps other valuable equipment, would be damaged. Two things were done to prevent such an occurrence.

First, the circuit shown in Fig. 2 is made inherently safe, in that failure of either tube to conduct will result in lowering the servo transformer to minimum, where it will remain. And second, included in the regulator circuit of Fig. 4 is a triode-operated relay which must be closed for the operation of the main high-voltage relay.

The grid of the 6J5 triode receives its bias from the difference between the voltage across $R_1$ and the auxiliary voltage source which is its plate supply. If this bias gets too high, (and it will if the servo transformer goes too high) the triode cuts off, opening its relay. The relay contacts are in series with the main high-voltage relay coil and thus all high voltage is removed. The main high-voltage relay (not shown) is so connected that it will not close except when the servo transformer is at minimum. When this main relay is open, the motor can lower the servo transformer, but cannot raise it. Thus, should the voltage across $R_1$ become excessive, the high voltage is shut off and cannot be applied except under safe conditions.

Ion bursts in some klystrons cause a sudden and severe surge in the beam current which may damage the power supply and its current meter. An over-current relay with contacts in series with the high-voltage relay coil, and a choke in series with the current meter, provide excellent protection from such overloading. The choke will delay meter deflection until the relay opens the main high-voltage relay. Tests indicate that with these safeguards, the power supply can be shorted or subjected to a sudden open-circuit without damage, that failure of any tube will not cause damage to any other part, and that interruption of the power line will safely shut the supply off. Magnetic breakers in the a-c lines provide additional protection against internal breakdowns and will operate within one-half cycle.

Tests show that the high-voltage regulator has a d-c output with less than three millivolts of ripple which is approximately the same at all output voltages. At 5,000 volts, this is $6 \times 10^{-6}$ percent and at 300 volts it is $1 \times 10^{-3}$ percent. When viewed on a high-gain oscilloscope, the output is practically free from transient jumps. It can handle a 3-ma or a 500-ma load with equal facility. The maximum output current of the regulator is limited only by the number of regulator tubes used.

### References

(1) Hogg, F. Livingston, Electronic Voltage Regulator, *Wireless World*, p 330, Nov. 1943.
(2) Middel, H. D., Electronics in Instrumentation, *Proc. of National Electronics Conference*, 1944, p.
(3) Hogg, F. Livingston, Electronic Voltage Regulator, *Wireless World*, p 329, Nov. 1943

### Bibliography

(1) A Voltage Regulator for DC Power Supplies, *RCA Application Note No. 96*, Aug. 24, 1938.
(2) Hunt, F. W., and Hickman, R. W., On Electronic Voltage Stabilizers, *Rev. Sci. Inst.*, 10, Jan. 1939.
(3) Bereskin, A. B., Voltage-Regulated Power Supplies, *Proc. IRE*, 31, Feb. 1943.
(4) Hill, Jr., W. R., Analysis of Voltage-Regulator Operation, *Proc. IRE*, 33, Jan. 1945.

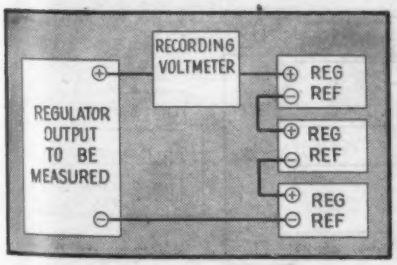



FIG. 5—Block diagram illustrating method of measuring drift

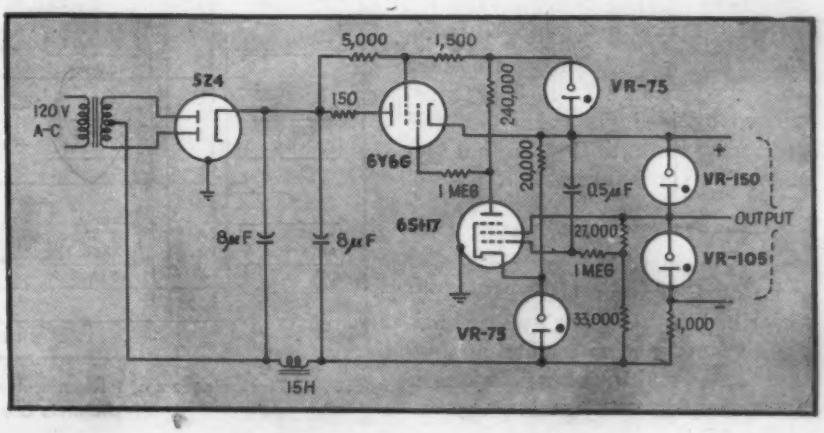



FIG. 6—Circuit of the auxiliary voltage source used for reference. This unit supplies plate voltage for the d-c amplifier of Fig. 4

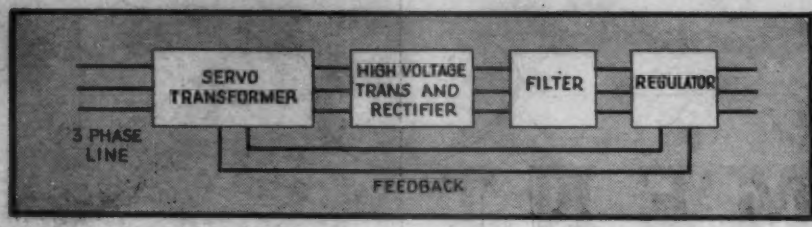



FIG. 1—Essential elements of the voltage regulator

is the regulated output. Although difficult to measure accurately, this ratio of the changes in voltages is estimated to be over 10,000.

Assuming the reference voltage to be constant, the most likely cause of voltage drift is the divider $R_1$, $R_2$. Resistor $R_1$ is a commercial one-watt, ½-percent, wire-wound precision resistor. The other, $R_2$, is a special variable resistor. The divider carries only 0.5 ma of current and the resistors dissipate only about 13 percent of their rated values. Thus the temperature rise, and hence the resistance change, is held to a minimum.

Various attempts were made to measure the drift, and because of the necessity of maintaining a bucking or reference voltage more constant than the voltage being measured, the system shown in Fig. 5 was used.

The regulated reference supplies are extremely stable and were thoroughly warmed up before the measurements were made. The voltage to be measured is adjusted to a value close enough to the total reference voltage to make the difference within the range of the recording voltmeter. This method shows a drift of less than 0.1 percent during the first five minutes of warm-up of the regulator, and not more than 0.01 percent at any time thereafter.

Resistor $R_2$ in Fig. 4 is made up of ten two-watt composition volume controls connected as rheostats. There are 475 volts maximum across each one and 4,750 volts across the ten. They are rated at 500 volts each.

The ten volume controls are mounted on vacuum-impregnated linen Bakelite and driven by gears made of impregnated Bakelite. The normal backlash in these gears provides the basis for a combination coarse and fine control of the regulated voltage.

When the control knob, which has a 12 to 1 ratio to the volume control gears, is turned in one direction, the first volume control alone changes its resistance. Then the second takes, and later the third, until finally, when all the slack is taken up, all ten are turning. At first, the control is ten times as fine as when all the volume controls are moving. When the control knob is reversed, it is again a fine control. On the panel, the knob is labeled, MASTER CONTROL: (Coarse; turn continuously. Fine; rock back and forth).

### Auxiliary Voltage Source

The regulated auxiliary voltage source is indicated by a block in Fig. 4, and is shown in schematic form in Fig. 6. It is an independent constant voltage source, although it may be operated from the same a-c line. In this case, it is supplied by one of the 208-volt lines and neutral. Therefore, the primary on the transformer is wound for 120 volts, single phase.

The output of the auxiliary unit is first electronically regulated and then again regulated by the glow-discharge tubes. This inverse-feedback regulator does depend upon a glow discharge tube for its reference, but only one type VR75 is used and it is supplied from the regulated side of the 6Y6G tube. The VR75 was selected because of its freedom from spasmodic variation found in other glow-discharge tubes. The slope of the top VR75 provides excellent compensation for the slope of the bottom VR75's.

### Safety Features

For the safety of inexperienced or careless operators, and for safety in servicing, a closed cabinet is used with an interlock switch, which opens the main three-phase relay when the rear door is opened. The regulated auxiliary voltage source and all filaments, except those in the servo-transformer control circuit, operate with the interlock open. The opening of the interlock prevents the application of any voltage to the autotransformer and prevents the operation of its control circuit. The high-voltage output jacks are located inside the cabinet, and leads to them are brought in through separate grommets. When there is any output voltage, no work can be done on the supply, and high-voltage connections cannot be made.

If failure in the control circuit of the servo transformer allowed it to run to its highest position, many times the proper plate voltage would be applied to the regulator tubes. Since this would be beyond the ability of the electronic regulator to correct, the output voltage would also

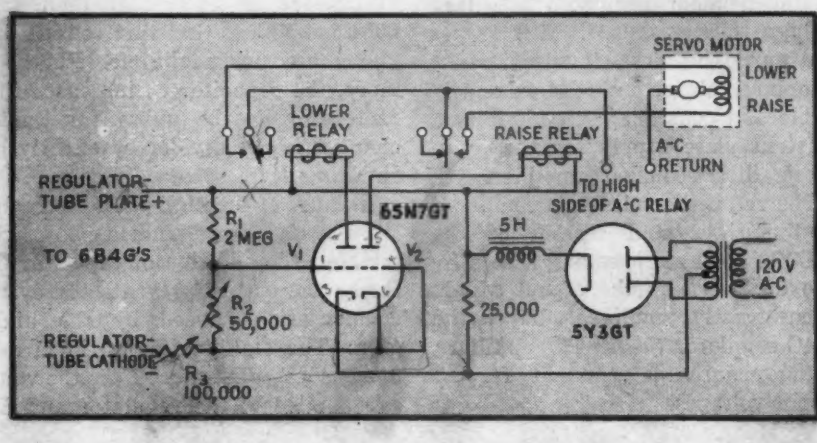
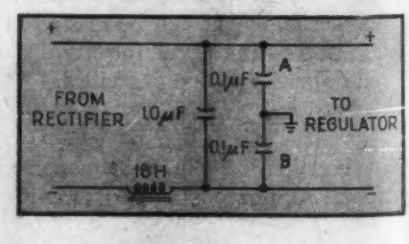
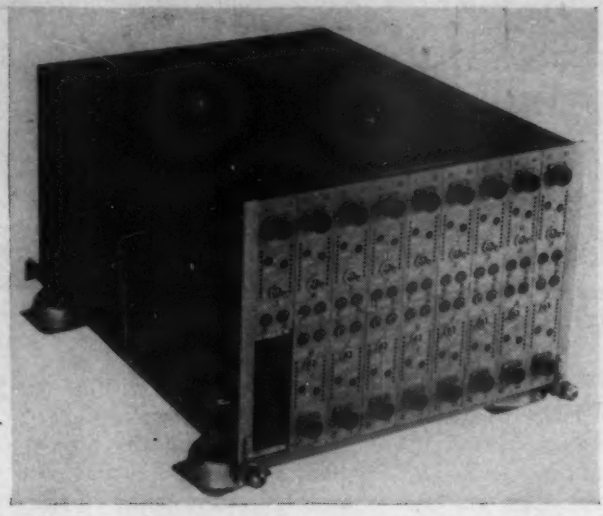


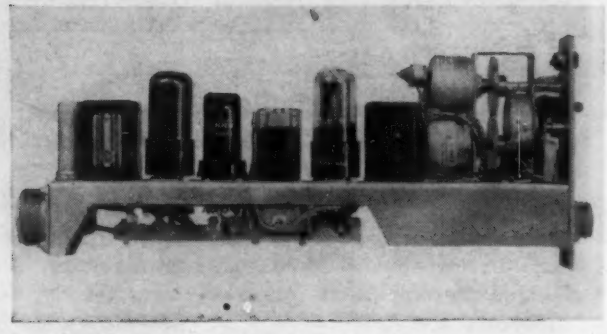

FIG. 2—Electronic circuit for control of the servo motor which is geared to the autotransformer

FIG. 3—Although the output of this filter cannot be grounded, capacitors *A* and *B* bypass to ground the high peaks caused by distributed capacitance of the transformer



# Electronic
# For





**Electronic commutator unit of airborne transmitter, with one of the 18 commutator channels removed and shown at right. Connectors go to bridge units of instrumentation being telemetered**

By LAWRENCE LEE RAUCH

*Princeton University*
*Princeton, N. J.*

IN the flight testing of modern high-performance military aircraft, often pilotless and radio-controlled, the aircraft may crash due to some failure. One method of obtaining and keeping records from various instruments in the aircraft is to transmit the readings by radio, as they occur, to a ground station where they are recorded. Thus, all records until the instant of the crash are available without risk of loss.

A separate radio link could be used to transmit the signal from each instrument, but this becomes impractical when the number of instruments to be telemetered is large. The telemetering problem then becomes one of multiplexing, where a number of signals are synthesized into a single signal which is transmitted by a single radio link and then analyzed into the original signals after reception.

### Commutation Multiplexing

The telemetering system developed at Princeton University and described in this paper uses an electronic commutation method of time division multiplexing wherein short samples of the various instrument or gage readings are converted into signals and transmitted in cyclic serial order. Twenty-one channels are used, and each one is sampled 952 times per second to give a repetition rate of 952 cps. The switching rate is then 952 x 21, or 20,000 cps (values are approximate).

The overall system is designed for an essentially uniform frequency response from 0 to 200 cps in each of the eighteen active channels (three are inactive). The short samples in each channel of the synchronized receiving commutator are integrated to provide a smooth signal for a recording galvanometer so that an exact record of the original instrument signal may be obtained.

### Operation of Transmitter

The block diagram in Fig. 1 illustrates the operation of the transmitter portion of the telemetering system. In effect, the heart of the

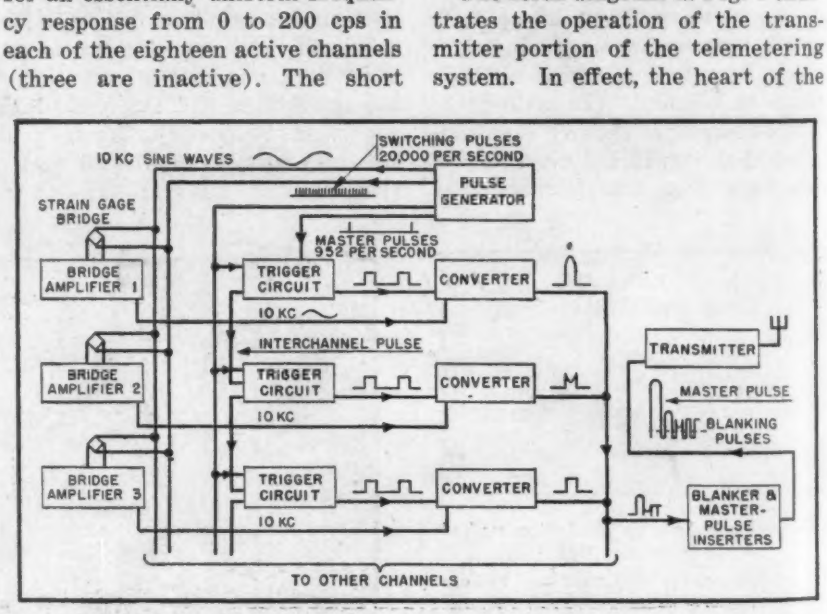



**FIG. 1—Block diagram of telemetering transmitter. A total of 18 active and 3 inactive channels are used in the system**

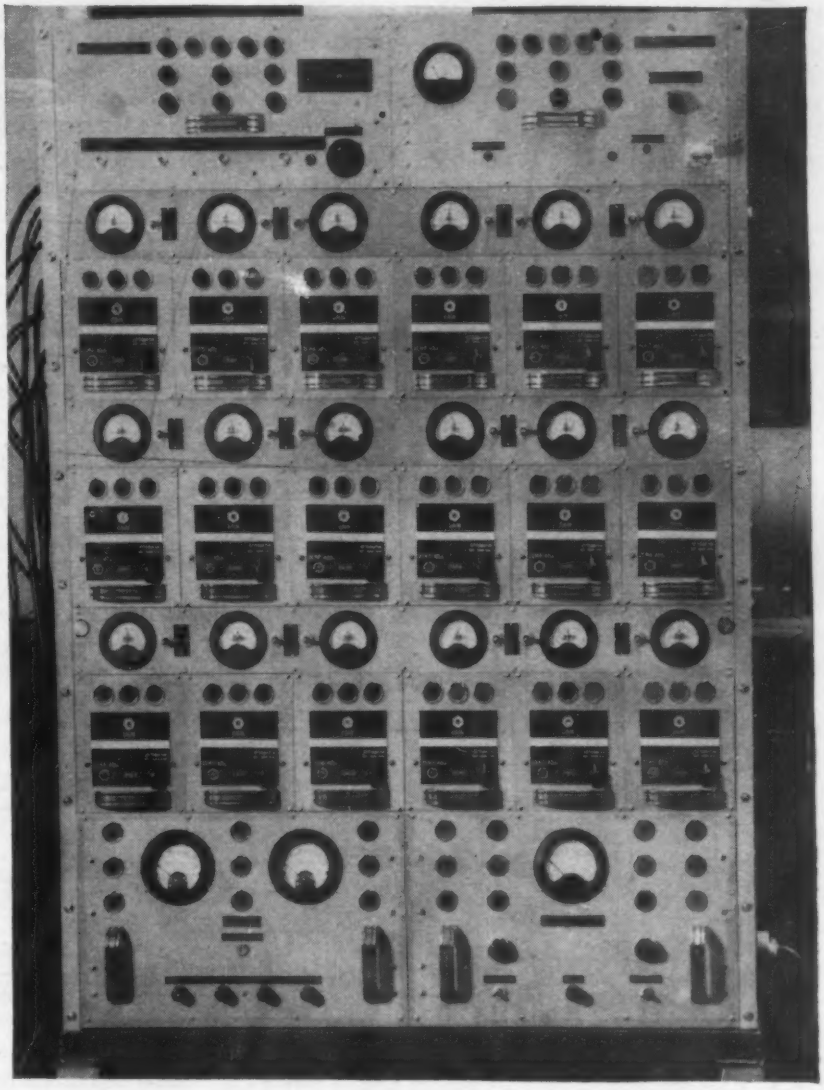
# Commutation TELEMETERING

**Readings of 18 bridge-type instruments are sampled in sequence 952 times per second by broken-ring trigger stages controlled by a master pulse generator, for transmission over an f-m radio link during flight tests of new aircraft or on pilotless runs**

system is the pulse generator located in the airborne transmitting equipment. This supplies 10,000-cycle sinusoidal voltage to drive bridge-type instrumentation, 20,000 switching pulses per second phased to occur each time the sinusoidal voltage crosses the zero axis, and 952 master pulses per second occurring simultaneously with each 21st switching pulse. Both the switching and master pulses are also sent over the radio link for receiver synchronizing purposes.

Certain instrumentation used in flight testing is well adapted to operation in bridge circuits, as for example strain gages and inductance accelerometers. The readings of other instruments can usually be converted to bridge unbalance voltages by potentiometers or other means, so this telemetering system has been developed to operate only with bridge-type instrumentation.

Alternating-current excitation is used to permit easy and reliable amplification of the small unbalance voltages from the bridges to the order of magnitude necessary for electronic switching. Rectification and its attendant difficulties are avoided by synchronizing the excitation waveform with the commutator sampling. A half-sine-wave sample of each bridge output from zero axis to zero axis is initiated by some switching pulse and is



Ground receiver commutator unit of telemetering system

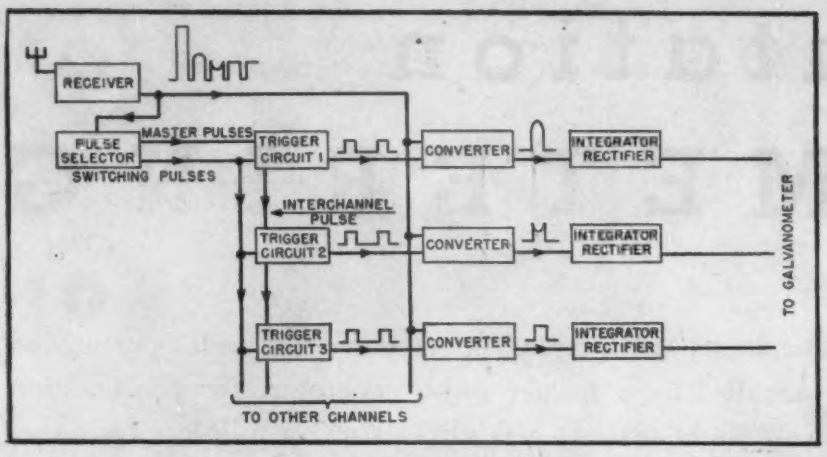



**FIG. 2—Block diagram of receiving equipment. The 18 trigger circuits are connected as a broken ring to provide accurate electronic switching to each channel in turn, with the process repeated 952 times per second**

terminated 50 microseconds later by the next switching pulse. The area under this half-sine-wave sample is proportional to the signal.

For sampling, each of the identical transmitting channels consists principally of a tuned 10,000-cycle bridge amplifier feeding into a converter (electronic gate circuit) controlled by a trigger stage. (The term converter rather than gate is used since the action of a gate operated at a fixed frequency is in general to modulate the gated signal onto the harmonics of the fixed frequency). The amplified, amplitude-modulated 10,000-cycle signal from the instrument bridge is present at the input of the converter at all times. At the proper time the converter is turned on by its trigger stage and the half-sine-wave sample passes through to the common output of the converters and on to the radio transmitter.

The entire commutation sampling sequence is thus controlled by the trigger stages. These operate on what is called the broken ring principle. The 20,000-cycle switching pulses are fed simultaneously to all trigger stages and have the effect of turning off any stage that happens to be on. Each master pulse fed to the first stage overcomes the action of the simultaneous switching pulse and turns the first stage on. The next switching pulse turns the first stage off, since there is no master pulse.

By the action of the first stage going off, an interchannel master pulse is fed to the second stage, turning it on in the same manner as the master pulse turned on the first stage. This process continues until the last channel is turned on by the preceding one and then off by a switching pulse. However, there is no interchannel master pulse connection from the last trigger stage to the first trigger stage,

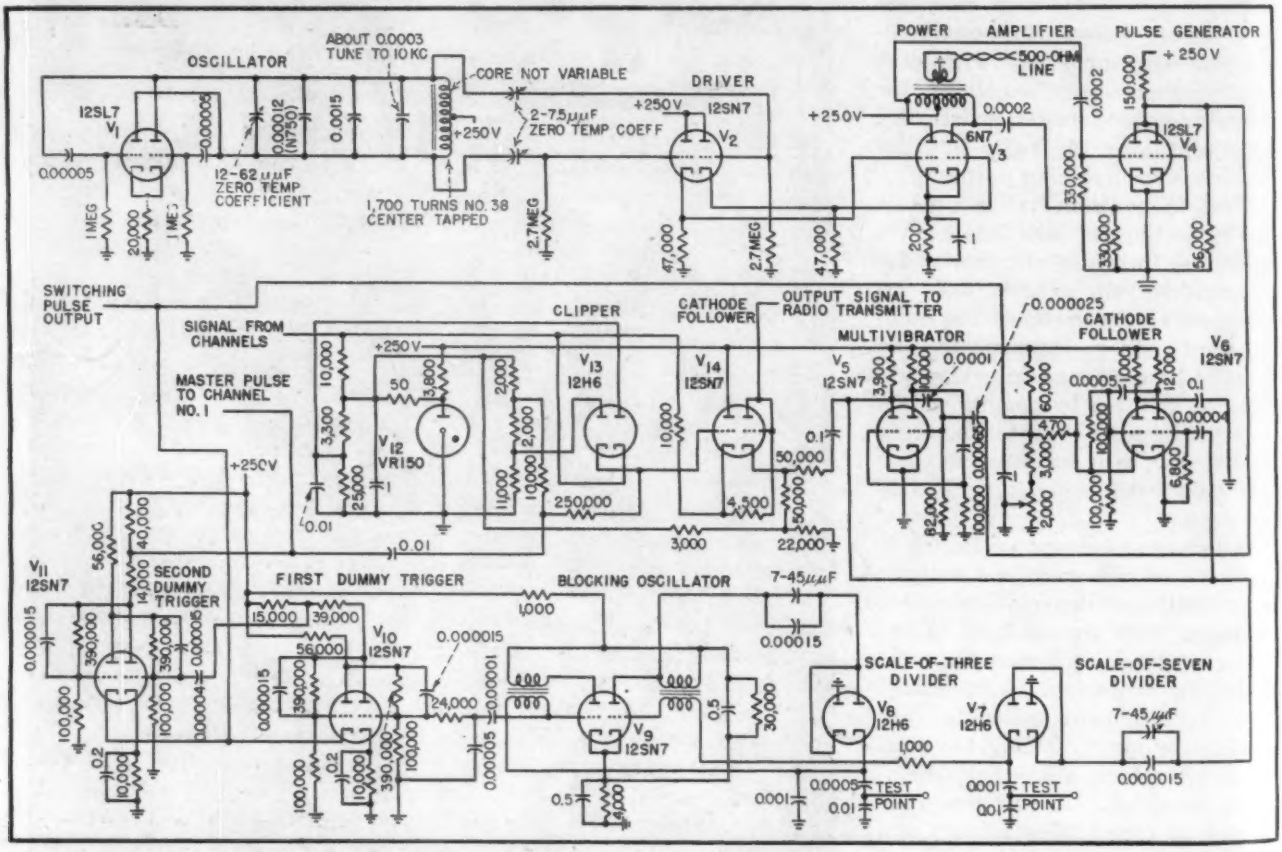



**FIG. 3—Pulse generator circuit of transmitter, used to generate 952 master pulses and 20,000 switching pulses per second as well as 10-kc power for bridge excitation**

so the switching sequence is ended until a new one is initiated by a master pulse from the pulse generator.

If the trigger stages are connected as a complete ring by starting the first channel with the interstage master pulse from the last channel, instead of by the master pulse from the pulse generator, the resulting switching action is entirely unsatisfactory. If an error in the switching once occurs, it remains. Two or more sequences may progress around the ring simultaneously, or a phase slip may occur, or the sequence may stop. These possibilities are particularly important at the receiving commutator which must be operated by radio link synchronizing pulses which are not infallible. If a switching error of any kind occurs in the present system using the broken ring principle, it will be corrected in not more than 1/952th second so that an error will not be carried for more than one sampling sequence.

Before the sequence of half-sine samples from the common output of the converters reaches the radio transmitter, it goes through blanker and master pulse inserters. Here it is limited in positive and negative directions, after which are added positive synchronizing master pulses above the positive limit level and negative synchronizing switching pulses below the negative limit level. The synchronizing master pulses occur during one of the three sampling intervals not used by the eighteen active channels. The synchronizing switching pulses occur between all sampling intervals and also serve as interchannel blanking pulses so that the required radio link modulation bandwidth for tolerable crosstalk levels is reduced.

### Operation of Receiver

At the ground receiving station, the output of the radio receiver is fed to the common inputs of all of the converters, as indicated in Fig. 2. The synchronized switching operation of the converters is accomplished in much the same manner as in the airborne commutator. The output of the radio receiver is also fed to a pulse selector, where master and switching pulses are

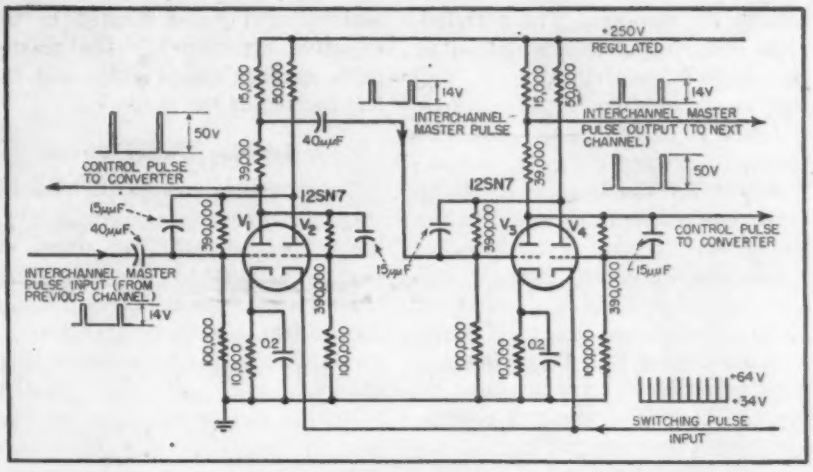



**FIG. 4—Trigger stages of two adjacent channels, showing interconnections to give broken-ring action**

generated in accordance with the respective synchronizing pulses on the radio signal. In this way the 50-microsecond samples from any given transmitting channel are connected to the proper receiving channel integrator and galvanometer.

The received samples consist of half-sine waves, proportional to the bridge unbalance voltage in the respective transmitting channel, added to pulses of constant height. Due to the number of channels being odd, the successive half-sine wave samples alternate in phase, which results in total samples whose areas are alternately larger and smaller. The amplitude of alternation is proportional to the desired channel telemetering signal. The frequency spectrum of the samples of the given channel then consists of constant components at even multiples of 476 cycles (half the repetition rate) and amplitude-modulated components proportional to the channel telemetering signal at odd multiples of 476 cycles.

The 476-cycle amplitude-modulated component arriving at the integrator-rectifier of a channel is selected by a low-pass filter which has little attenuation below 700 cycles and at least 60 decibels of attenuation at 952 cycles and above. The amplitude-modulated 476-cycle sinusoidal signal at the output of the filter is amplified and then demodulated by a balanced full-wave rectifier, followed by a low-pass filter attenuating above 200 cycles to eliminate the 952-cycle and higher components. The demodulated output of each channel is usu-

**One channel of commutator unit at ground station. Low-pass pulse filter is at right rear on chassis**

ally connected to a recording galvanometer having a uniform response from 0 to 200 cycles.

The pulse generator circuit of the transmitter, shown in Fig. 3, employs a 10,000-cycle pushpull tuned-plate oscillator using a 12SL7 double-triode tube $V_1$. The tuned circuit is temperature compensated and a frequency-adjusting trimmer capacitor is provided. The relatively strong signal from this oscillator excites a 6N7 untuned class B power amplifier $V_2$ through a 12SN7 cathode-follower driver $V_3$. Capacitance attenuators are provided at the input of the driver to adjust the output and balance of the power amplifier. A power output of 5 watts at 10,000 cycles is furnished to a 500-ohm line for excitation of instrumentation.

A 12SL7 push-push pulse generator $V_4$ is fed from the plates of $V_3$. A positive pulse occurs each time the 10,000-cycle sinusoidal signal

crosses the zero axis. These 20,000-cycle positive pulses are shaped by the 12SN7 multivibrator $V_5$ and emerge from the 12SN7 cathode follower $V_6$ as switching pulses for the channel trigger stages. An adjustment for the base level of the switching pulses is provided in the circuit of $V_6$.

The shaped pulses from $V_5$ are also fed to a 12H6 scale-of-seven divider $V_7$ and then to a 12H6 scale-of-three divider $V_8$. Two triggered blocking oscillators are provided by the 12SN7 $V_9$ for the two scaling circuits. The resulting pulses, occurring every twenty-first switching pulse, have been delayed in phase by the scaling circuits and are used to operate a 12SN7 dummy trigger stage $V_{10}$. This trigger stage has no accompanying converter and is used merely to supply interchannel master pulses in the proper phase to the second 12SN7 dummy trigger stage $V_{13}$, which furnishes the full-width 50-microsecond synchronizing master pulses for the radio link and the master pulses for the first commutator channel.

The common synthesized signal from the channels is limited in the positive direction by the characteristic of the converters and in the negative direction by the right section of the 12H6 diode clipper $V_{12}$. The synchronizing master pulses from $V_{11}$ are added to the signal by the cathode-follower-connected left section of the 12SN7 $V_{14}$. The blanking pulses (also synchronizing switching pulses) are added to the signal by the multivibrator $V_5$ and the diode-connected right section of $V_{14}$ and limited in the negative direction by the master pulse cathode follower $V_{14}$ and the left section of the diode $V_{12}$.

### Broken-Ring Trigger Circuit

Two consecutive stages of the 18-stage trigger chain controlled by the pulse generator are shown in Fig. 4 to illustrate how electronic commutation is achieved in the transmitter. Each trigger tube is stable with either side conducting, although each of the positive switching pulses will stop conduction in the right side (turn the stage off) if it happens to be conducting, thereby placing the left side in a conducting state.

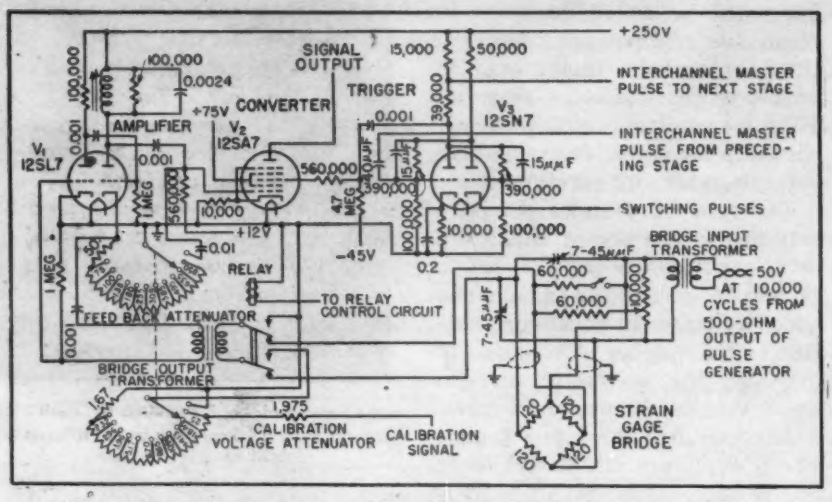



FIG. 5—Circuit of one of the 18 commutator channels in the transmitter

If the first stage shown is turned off by a switching pulse, the negative interchannel master pulse from the plate of $V_1$ will stop conduction in the left side of the second stage ($V_2$), thereby turning it on. This process continues from stage to stage.

The circuit of one of the 18 identical transmitting channels is given in Fig. 5. Here $V_2$ corresponds to one of the trigger tubes in Fig. 4. The 50-microsecond positive pulse from the left plate of $V_2$ is used to turn the 12SA7 converter tube $V_2$ on for its allotted interval. During the rest of the time the third grid of the converter tube grid is biased below cutoff by a 45-volt battery.

A portion of the power in the 500-ohm, 10,000-cycle circuit from the pulse generator is delivered to the 120-ohm strain gage bridge at approximately 5 volts by the bridge input transformer. The bridge circuit contains a potentiometer for resistance balance and two variable capacitors for capacitance balance. Experience has shown that the capacitance balance in any installation is very stable. The toggle switch provides a known fixed unbalance for single-point calibration purposes.

Normally the 10,000-cycle amplitude-modulated bridge output passes through the bridge output transformer to the 12SL7 two-stage tuned amplifier $V_1$. The signal from the output of the amplifier is present at all times at the input to converter $V_2$. The amplifier employs inverse feedback from the cathode of the second stage to the grid of the first stage. Eleven calibrated steps of attenuation are provided by a tapped resistor in the cathode of the second stage, sufficient inverse feedback being maintained at the minimum attenuation position.

### Automatic Calibration

A comprehensive automatic calibration system is incorporated in the commutator of the transmitter so that overall accuracies of the order of one percent can be obtained by recording a calibration directly before and after a test maneuver of the aircraft. Two automatic selector switches are arranged so that in a period of approximately eighteen seconds each channel will separately have ten calibration points plotted covering its full range. Each channel is disconnected from its instrument for one second by its relay while the ten calibration voltages are applied by the automatic selector switch.

When a channel is calibrated by this automatic system, the relay in Fig. 5 operates and the output from the 25-ohm tapped voltage divider is applied to the input of the amplifier in place of the strain gage bridge. The voltage divider is coupled to the attenuator so that the calibration covers the full modulation range of the channel for each attenuator setting. At maximum gain a stress of approximately 10,000 psi on dural on one arm of the bridge will cover the full modulation range.

In Fig. 6 is shown the waveform of a single commutation sequence as fed into the pulse selector from

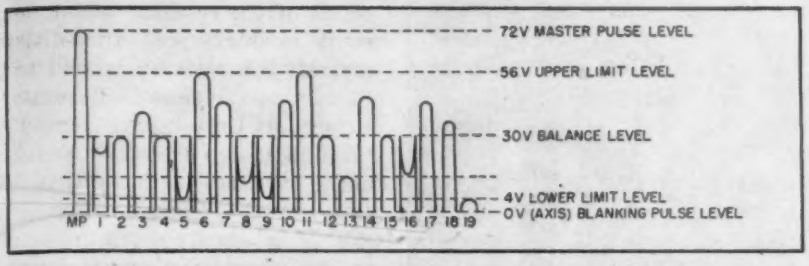

72V MASTER PULSE LEVEL
56V UPPER LIMIT LEVEL
30V BALANCE LEVEL
4V LOWER LIMIT LEVEL
0V (AXIS) BLANKING PULSE LEVEL
MP 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

**FIG. 6—Signal pattern at transmitter commutator output, showing one entire commutation cycle including master pulse MP**

the output of the radio receiver. Referring to the circuit of the pulse selector in Fig. 7, the large negative blanking pulses from the radio receiver (absolute value of peaks is zero) applied to the grid of the 12SH7 tube $V_1$ cause corresponding positive pulses at the plate, while the more positive portions of the signal of Fig. 6 are lost due to the biasing action of the circuit.

#### Pulse Selector in Receiver

The 12SH7 tube $V_2$ drives a 20,000-cycle tuned circuit of moderate $Q$ to provide a stabilized sinusoidal signal synchronized with the blanking pulses. The output of the tuned circuit is then shifted in phase and passed through a two-stage square-wave generator consisting of the left section of the 12SN7 $V_3$ and the 12SH7 $V_4$. The 20,000-cycle square wave is differentiated and the positive pulses are selected and delivered at low impedance by the cascade cathode followers of the 12SN7 $V_5$ for use as switching pulses for the receiving commutator channels.

Having thus traced through the switching pulse section of the pulse selector, we return to the signal of Fig. 6 and the problem of selecting the positive synchronizing master pulse. This positive pulse on the grid of the 12SH7 $V_6$ causes a corresponding negative pulse at the plate, while the more negative portions of the signal are lost due to the positive bias on the cathode.

The negative pulse is applied to the right grid of the 12SN7 $V_3$, thereby permitting the capacitor in the cathode circuit to discharge slowly through the resistor across it. If the pulse is long enough, the potential of the paralleled cathodes of the right section of $V_3$ and the left section of the 12SN7 $V_7$ will decrease to such a value that the multivibrator circuit of $V_7$ will trigger and deliver a negative pulse at the left plate. This negative pulse acts as a master pulse for the dummy trigger circuit of the 12SN7 $V_8$ (for it controls no converter), which in turn supplies an interchannel master pulse to operate the first channel of the commutator trigger chain.

The dummy trigger circuit is incorporated in the pulse selector because the master pulse from $V_7$ comes relatively late during a sampling period due to the delay action of the selection circuit, which insures that short noise pulses will not be mistaken for the longer 50-microsecond synchronizing master pulses.

#### Receiver Commutator Channel

The receiver commutator trigger chain is identical with that of the transmitter except that it is operated by the pulse selector instead of the pulse generator. The circuit of one receiver commutator channel is given in Fig. 8. The 12SN7 $V_1$ is used in the familiar trigger circuit. However, the 12SN7 double cathode follower converter $V_2$ is operated by negative control pulses from the trigger stage. The cathode of the left section normally holds the cathode of the right section at such a high potential that the latter is cut off. During the on period of the channel the negative pulse from $V_1$ cuts off the left section of $V_2$ and allows the right section to gain control and conduct the channel sample as a cathode follower. Thus the channel sample pulses at the cathode of $V_2$ are in the negative direction. These channel samples

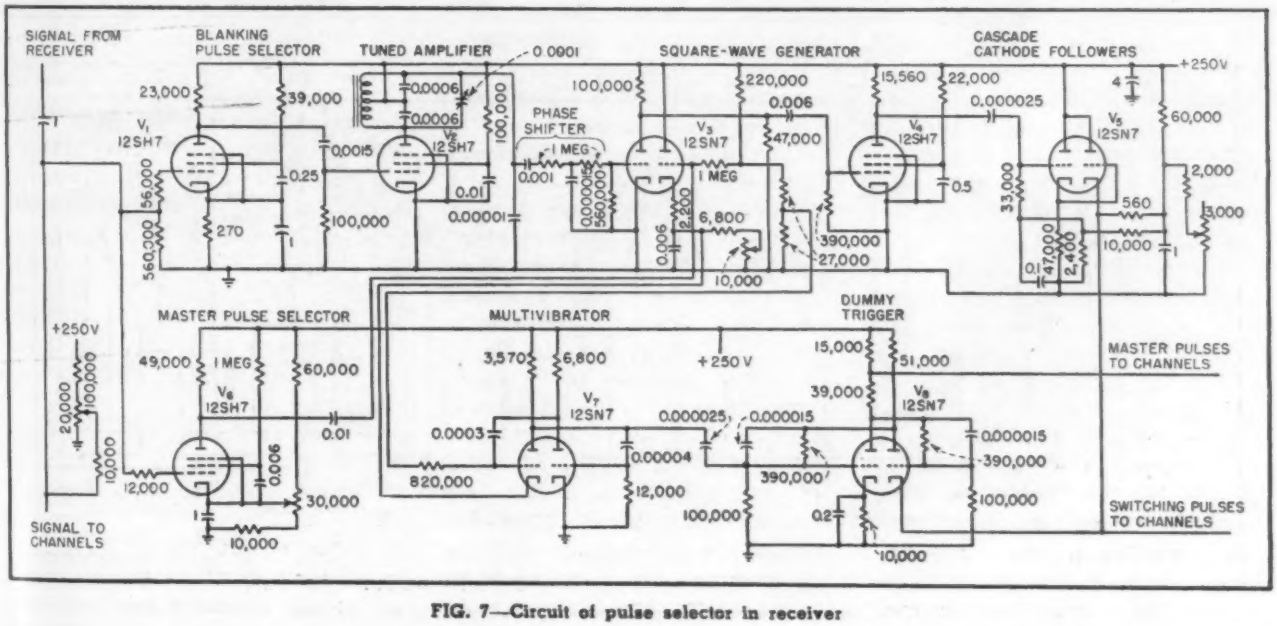


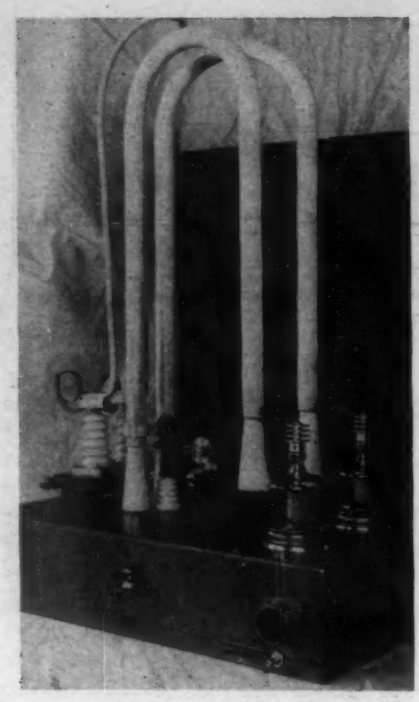

**FIG. 7—Circuit of pulse selector in receiver**

from the 12SN7 phase inverter and cathode follower $V_3$ are delivered to the following pulse filter as positive pulses. As previously explained, the output of the pulse filter is a 476-cycle sinusoidal signal amplitude modulated by the channel intelligence. This passes through a highly stabilized three-stage amplifier using $V_4$ and $V_5$.

The left section of the 12SL7 acts as a voltage amplifier, driving the right section operating as a cathode follower phase inverter to drive the push-pull 12SN7 output stage. The amplified amplitude-modulated 476-cycle sinusoidal signal is then demodulated by a full-wave copper-oxide rectifier and low-pass filter. Balancing current is supplied from a 12-volt d-c source by a potentiometer before the signal is delivered to a recording galvanometer. A maximum peak-to-peak output of approximately 20 milliamperes is available for the galvanometer. This may be reduced by means of a gain control in the inverse feedback loop.

### Radio Link

Any deviation from a linear response in the radio link will appear identically in all channels as a deviation from linear response, but no crosstalk or noise will result. To maintain crosstalk below tolerable limits it is necessary for the amplitude - versus - frequency response of the radio link to be uniform between certain limits. In the present system these limits can be shown to be approximately 250 and 70,000 cycles for adjacent-channel crosstalk below 50 decibels. The maximum air-to-ground range is 15 to 25 miles.



**Power amplifier of f-m transmitter used at Bikini as the radio link for the telemetering system described**

### Acknowledgment

The equipment described herein, known as the NDRC Telemetering System Type 2 Model A, is a partial result of the research and development in high-speed time-division aircraft telemetering carried on at Palmer Physical Laboratory, Princeton University, from 1943 through 1946. The work was done under contract with Section 17.2 of NDRC. The writer was one of a small group, now dispersed, whose members contributed the ideas leading to the equipment described.

This equipment is the result of considerable flight test experience with P59, F7F and P80 aircraft gained with the earlier Type 1 Model B telemetering system in close cooperation with the Bell Aircraft Corporation during the latter part of 1944 and early part of 1945. The sampling method of this earlier system required the radio link to transmit a slowly varying d-c component.

The present system employs, among other things, an altered sampling method requiring a more easily obtainable lower limit of 250 cycles for the radio link frequency response. Two of these systems were recently used at Bikini on Operation Crossroads to telemeter air pressures at 18 locations on each of two target ships, using a frequency-modulated transmitter as the radio link. Maximum frequency deviation was 150 kc, frequency response was uniform from 0 to 70,000 cycles, and power output was 700 watts.

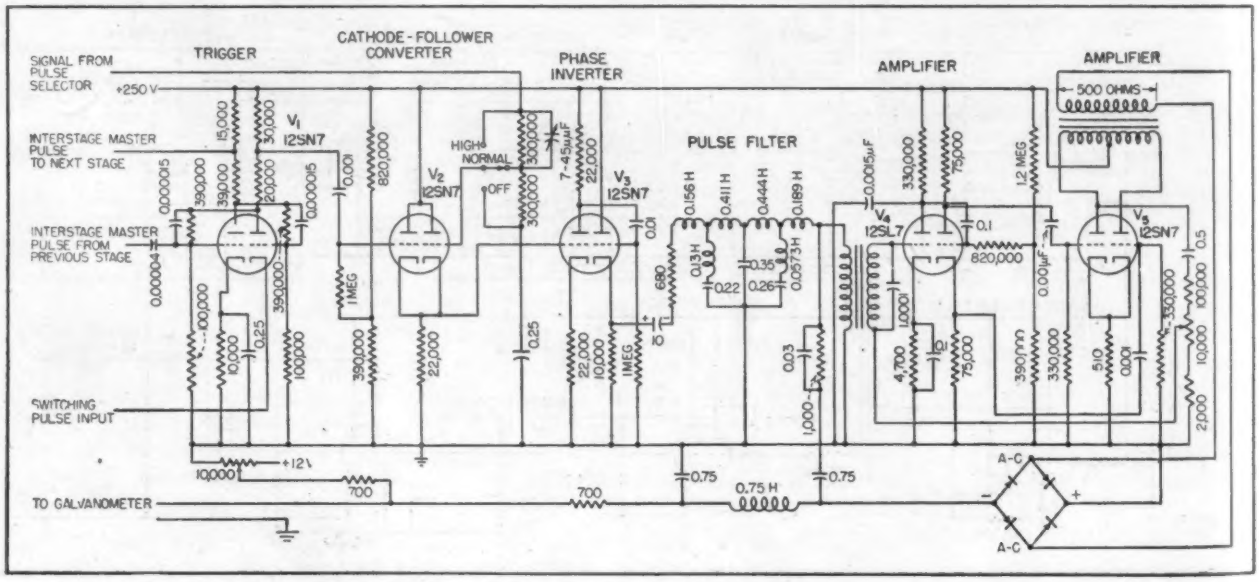



**FIG. 8—Circuit of one of the 18 commutator channels in the receiver**

By EDWARD KASNER

*Assistant Engineer*
*Kollsman Instrument Division*
*Square D Company*
*Elmhurst, N. Y.*

# Tachometric Audio-Frequency Meter

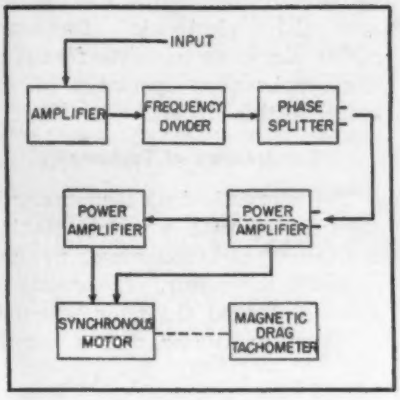



FIG. 1—Block diagram of tachometric audio-frequency meter

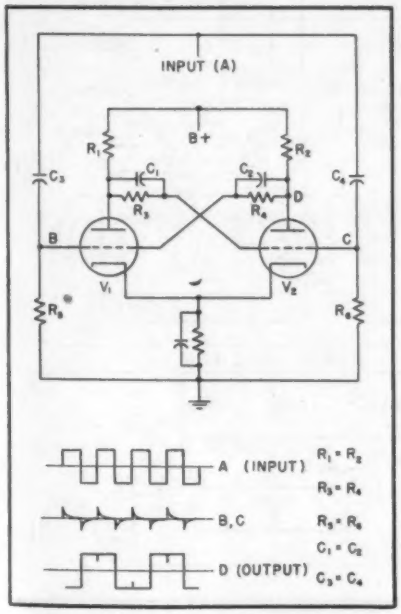



FIG. 2—Basic Eccles-Jordan circuit used to lower input frequency sufficiently to drive a synchronous motor, with input, output, and grid-voltage waveforms

**Eccles-Jordan scale-of-two trigger circuits divide the audio input frequency and produce two-phase output for driving a synchronous motor and magnetic drag tachometer. Frequencies from 30 to 450 cycles are indicated directly by pointer with 0.5-percent accuracy**

DIRECT-READING, wide-range electronic audio-frequency meters are seldom capable of maintaining an accuracy of better than two percent. Limiting factors such as supply-voltage regulation, temperature variations, and the aging of tubes and circuit components can be compensated for only to a limited degree.

During the development of a more accurate frequency meter, investigation was made of all conventional methods of frequency measurement. The device which within reasonable limits proved to be the most dependably independent of variables other than frequency was the combination of a synchronous motor and magnetic drag tachometer shown in block form in Fig. 1. Its adaptation for the purpose of frequency measurement in conjunction with suitable electronic circuits is herein described.

The characteristics of a synchronous motor are such that although it will maintain constant speed at any rated load, its torque when out of synchronism is very low. Also, in order to realize a fair degree of efficiency and good starting characteristics, the motor must be of polyphase construction.

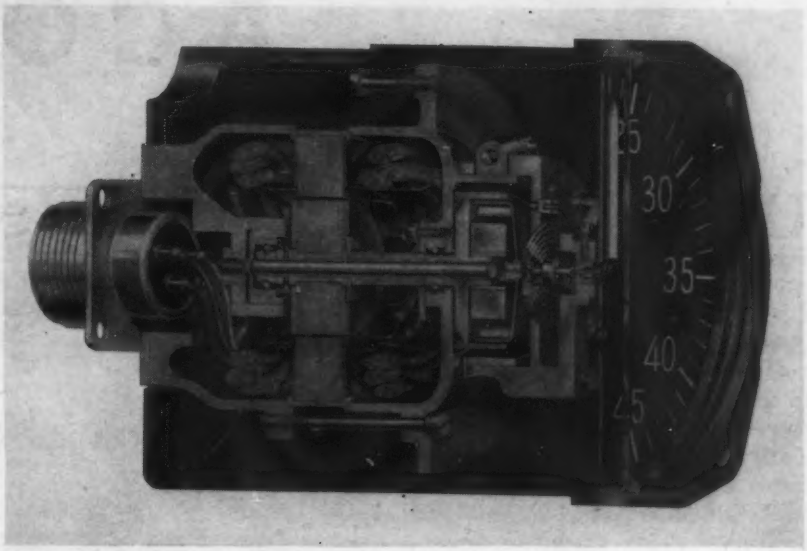
The use of a polyphase (two-phase) motor necessitates the inclusion of a phase-splitting circuit in order that the frequency-meter input be single-phase. Since the range of frequencies through which a synchronous motor will remain synchronous is limited (from about 10 to 150 cycles for a good 60-cycle motor), frequency dividers are required for range extension.

### Frequency-Divider Circuit

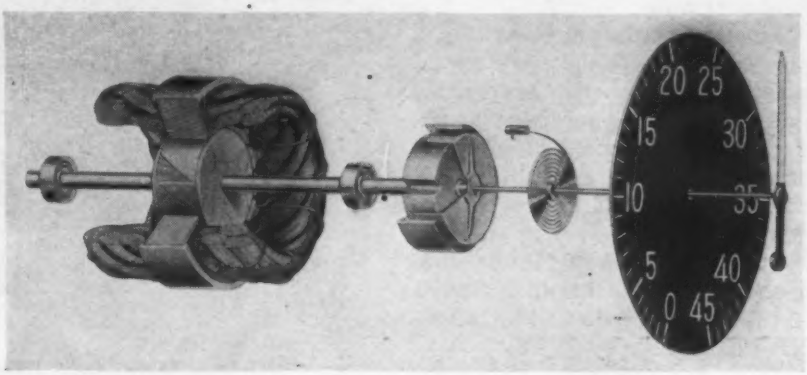
The Eccles-Jordan scale-of-two circuit shown in Fig. 2 provides a reliable frequency divider. Resistors $R_1 - R_3 - R_5$ and $R_2 - R_4 - R_6$

cup. A rotating permanent magnet within the cup, driven by the synchronous motor, sets up eddy currents in the cup, producing a shaft torque proportional to the speed of magnet rotation. The torque, acting against the spring, causes a shaft displacement proportional to the torque. The pointer indicates the speed on a dial calibrated in cycles per second.

The drag cup is made of a special alloy with a very low temperature-resistance coefficient. The magnet is seasoned and is compensated for temperature errors. The effect of age upon accuracy is negligible. Overall accuracies better than half of one percent can be maintained in normal use.




Cutaway view of synchronous motor, magnetic drag tachometer, and indicating scale




Exploded view of rotating parts of motor and tachometer, showing permanent magnet at right end of synchronous motor shaft and copper cup at left end of tachometer shaft. Eddy currents induced in cup by magnet cause tachometer shaft to be displaced against spring torque in proportion to speed of magnet rotation

### Complete Circuit

The complete circuit of an experimental unit designed to operate from 30 to 450 cycles is given in Fig. 4. Here the outputs from the frequency dividers are not taken directly from the plates but from taps in the load resistors, to prevent instability due to loading.

If one phase of a two-phase motor is reversed, the direction of rotation will be reversed. In order to prevent the instrument from reading backwards, the load resistors of the second dividers are made unequal ($R_2 + R_3 = 1.5R_1$). This unbalance assures consistency in the firing order of the second dividers. The simultaneous reversal of both phases will not affect the direction of rotation. Therefore, the first divider requires no unbalance.

The problem of varying input waveform is taken care of by trigger circuit $V_6$ preceding the first divider. Except that the input is applied to one grid and the static voltage distribution is changed, this circuit operates in a manner similar to the frequency divider. Its output is either a square or rectangular wave, regardless of input waveform. The only input limitation is that the unknown frequency be periodic. If it should be necessary to determine the average frequency of an aperiodic input, the trigger circuit would have to be replaced by some sort of integrating or averaging circuit.

Since the impedance of the motor varies with the frequency applied, the method of coupling the motor to the power amplifiers must be free of matching errors. This is easily done by using large electrolytic capacitors (20$\mu$f for $C_1$ and $C_2$) directly between the plates and the motor.

Voltage amplifier $V_1$ precedes the trigger circuit. The sensitivity of the frequency meter is determined by the gain of the amplifier and can be extended as desired by the use of a pentode or another stage. Range extension can be accomplished through the use of additional frequency dividers preceding the first divider.

The power amplifier design is determined chiefly by the requirements of the motor used. For a motor rated at about 50 ma at 100 volts (per phase), the circuits of $V_6$ and $V_7$ suffice. Variations, such as inverse feedback and class-B output, would probably be required if the motor were larger or a range of frequencies greater than ten to one were to be used.

The foregoing combination of frequency divider, synchronous motor, and magnetic tachometer provides an excellent device for the measurement of audio frequencies. In comparison with available commercial frequency meters, it offers an increase in accuracy of better than 400 percent.

impress bias voltages on the grids of $V_1$ and $V_2$. Due to slight circuit inequalities, one tube (say $V_1$) conducts more current than the other. The larger voltage drop across its load resistor $R_1$ causes a decrease in current through $V_2$. This in turn causes a smaller drop across $R_2$, and $V_1$ conducts even more current. The tendency is to drive one tube toward cutoff and the other toward saturation. Actually, one grid is kept at about zero (because of grid current) and the other is driven well beyond cutoff.

When a square-wave input is applied at $A$, $C_3 - R_3$ and $C_4 - R_4$ differentiate the square waves, and sharp full-wave pulses appear at $B$ and $C$. When a positive pulse appears, the conducting tube undergoes no change. The nonconducting tube attempts to conduct but is prevented from doing so by the high negative bias impressed upon it by the other tube.

When a negative pulse appears, both tubes are momentarily driven to cutoff. The charges existing across $C_1$ and $C_2$ can now exert control over the circuit. The higher charge across $C_1$ causes $V_2$ to conduct more current and, through the process previously described, $V_1$ is driven to cutoff. One input cycle causes one transfer of conduction, and two input cycles cause one cycle of conduction transference.

### Two-Phase Output Circuit

The use of the Eccles-Jordan circuit to extend frequency range and simultaneously produce a two-phase output from a single-phase input is believed to be new. The method whereby this is done is shown in Fig. 3. Two dividers, each driven from a plate of the first divider, receive signals having 180 degrees difference in phase. Due to the frequency-dividing action, their outputs are 90 degrees out of phase. The principle underlying this arrangement is that the second subharmonics of two signals of the same frequency and of 180 degrees phase displacement are 90 degrees out of phase.

If $V_3$ and $V_4$ drive power amplifiers whose loads are the fields of the synchronous motor, the motor will run at a speed proportional to one-fourth the input frequency. Conditions which would be limiting factors in the accuracy of a conventional electronic frequency meter can in no way interfere with the synchronous operation of the motor in this circuit.

### Construction of Tachometer

The magnetic drag tachometer is used to operate a direct-reading indicator corresponding to the speed of the motor. It consists of a spring-loaded shaft, on which is mounted a pointer and a copper

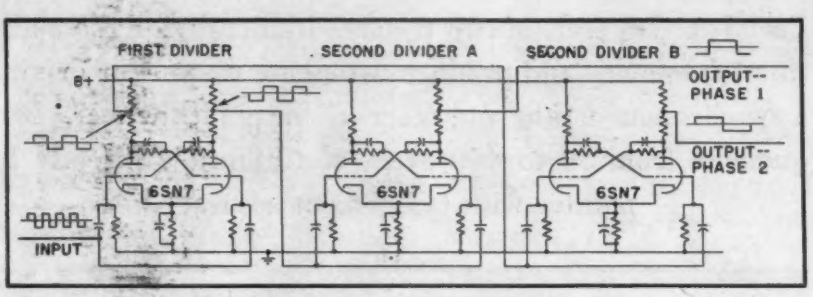



FIG. 3—Use of Eccles-Jordan circuits to produce two square-wave outputs differing in phase by 90 degrees

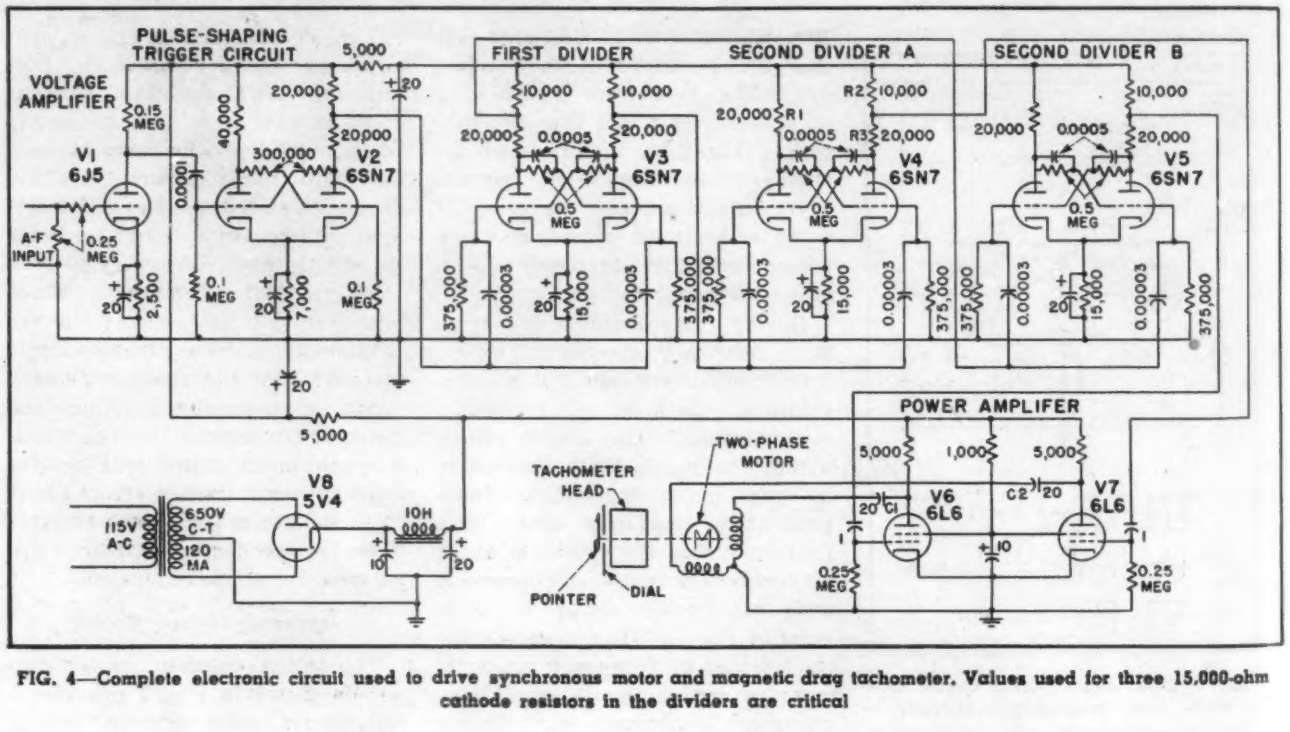



FIG. 4—Complete electronic circuit used to drive synchronous motor and magnetic drag tachometer. Values used for three 15,000-ohm cathode resistors in the dividers are critical

# LOCATING SYSTEM

**A supersonic beeper, installed in a torpedo, produces a 24.5-kilocycle sound wave that is picked up by a directional magnetostriction hydrophone in a search vessel. Final location of a lost torpedo is done by a diver carrying a portable hydrophone**

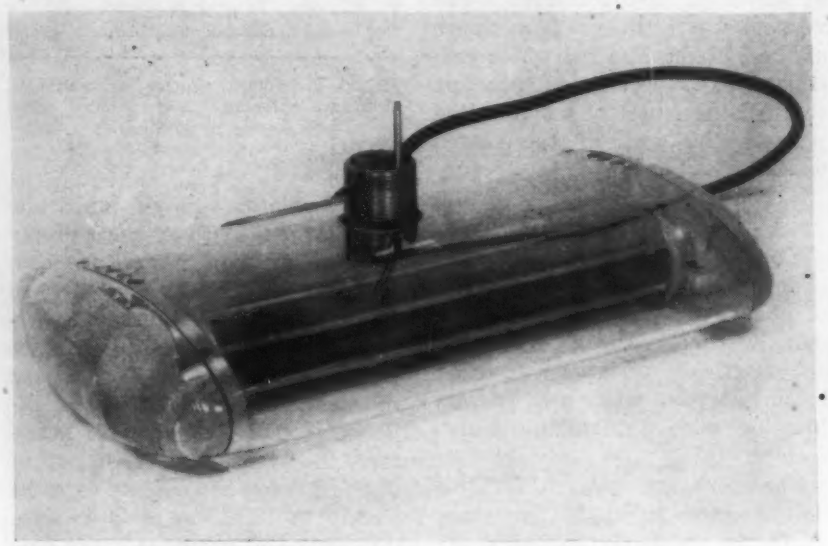


**FIG. 3—Magnetostriction listening hydrophone in its streamlined plastic housing. Magnet and coil assemblies inside a nickel tube form the transducer**

netic polarization. Alternating current from the oscillator-amplifier flows through the coil and produces the driving force to set the magnetostrictive tube into oscillation. The tube and its diaphragm comprise a mechanically resonant system so that the conversion of electrical to acoustical energy is achieved with high efficiency at the resonant frequency. This frequency depends primarily on the length of the nickel tube, which is approximately one-quarter wavelength.

The chosen frequency is a compromise between two conflicting factors: The range is increased as the frequency is lowered; and for given physical dimensions of the receiving hydrophone, the principal sound beam becomes sharper as the frequency is increased.

A frequency of 24.5 kilocycles was chosen because satisfactory range could be obtained, and the dimensions of the receiving hydrophone were not too large at this frequency.

### Range

With a ten-volt signal at the resonant frequency impressed upon the coil of the transducer, the acoustic field at a distance of one meter in the direction of maximum intensity is from 30 to 35 db above one dyne/cm². Ideally, the projector would be nondirectional, but when mounted on one side of the 20 to 22-inch diameter torpedo shell, the shell causes the acoustic signal to differ by 10 to 15 db in different directions. Thus, the intensity of the sound field one meter away in the direction of minimum output is about 20 db above one dyne/cm².

Assuming an inverse square law of diminution of the field with distance and taking −20 db versus one dyne/cm² as a threshold signal strength, a maximum operating range is set at about 1,100 yards. In operation, using the directional receiving hydrophone and the receiving amplifier to be described, an average unit receiving from 80 to 90 volts at 23 to 25 kilocycles from the oscillator-amplifier produces an excellent signal at 550 yards, and a detectable signal at 880 yards to 1320 yards, depending upon water conditions.

### Listening Equipment

The hydrophone for the listening equipment must be directional enough to locate the missing torpedo, but not too sharp so that training the projector would be difficult. To fit this requirement, a magnetostriction hydrophone was developed.

The active element of the magnetostriction unit is a nickel tube about 12 inches long with 1½-inch outside diameter and 0.035-inch wall thickness. Three magnet and coil assemblies are placed inside the tube, the middle magnet and coil assembly being 5 inches long, while each of the two end coils is half the physical size of the center one and has half the number of turns. This produces a shading effect which reduces the minor lobes of the pattern, giving the desired sharpness.

Three bar magnets are used to produce a magnetic field in the nickel tube. The poles of the magnets appear along their edges, which are flush with the inside surface of the tube. Two half-cylindrical wooden forms are placed on either side of the magnets to form a cylindrical assembly which fits within the nickel tube. This assembly is small enough to permit wire to be wound on the cylinder to form a coil. The first turn of the coil is wrapped around one of

# ACOUSTIC

By ERIC A. WALKER and PAUL M. KENDIG

*Ordnance Research Laboratory*
*The Pennsylvania State College*
*School of Engineering*
*State College, Pa.*

UNDERWATER locating equipment has been developed by the Harvard Underwater Sound Laboratory for finding torpedoes lost during test runs.

An oscillator-amplifier and a magnetostriction projector are mounted in the torpedo. The oscillator unit, powered by the main battery in the electric torpedo or by special batteries in the air or steam torpedo, delivers a supersonic signal to the projector, which transmits an almost nondirectional sound beam of moderate intensity into the surrounding water.

Mounted on the searching ship is the second part of the equipment, a directional receiving hydrophone and a heterodyne receiving amplifier. The directional hydrophone is trained to receive a maximum signal. This signal is heterodyned in the receiving amplifier to an audible tone which is heard in the loudspeaker. The vessel is then steered in the direction indicated by the receiver.

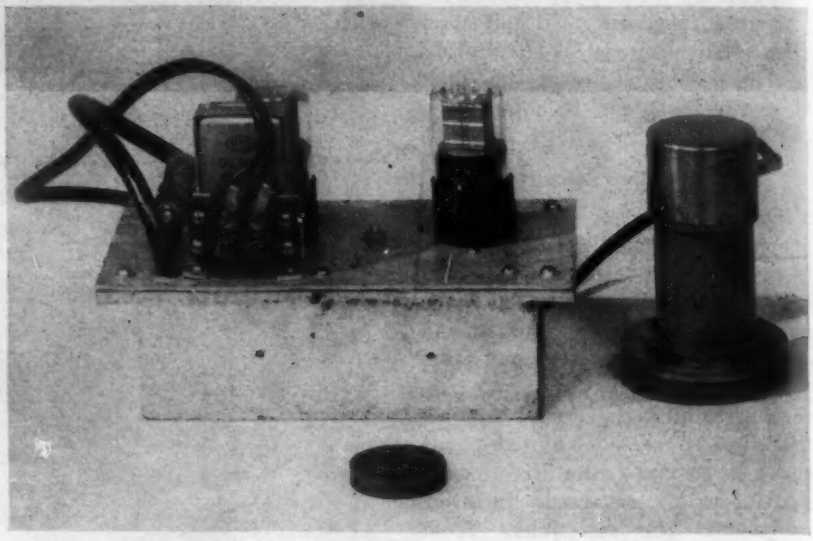


FIG. 2—Electronic portion of the transmitter, the transducer, and the rubber pad that clamps between the transducer diaphragm and the shell of the torpedo

### Transmitter

The two-stage oscillator-amplifier employs two 3Q5-GT tubes, one of which operates as a frequency-stabilized oscillator driving the output stage. The schematic diagram of Fig. 1 shows the circuit of this unit. Both filament and plate current are supplied from the storage batteries of an electric torpedo, and with a supply voltage of 150 volts an acoustic signal in excess of one-half watt is transmitted to the water. Figure 2 shows the oscillator-amplifier assembly and projector.

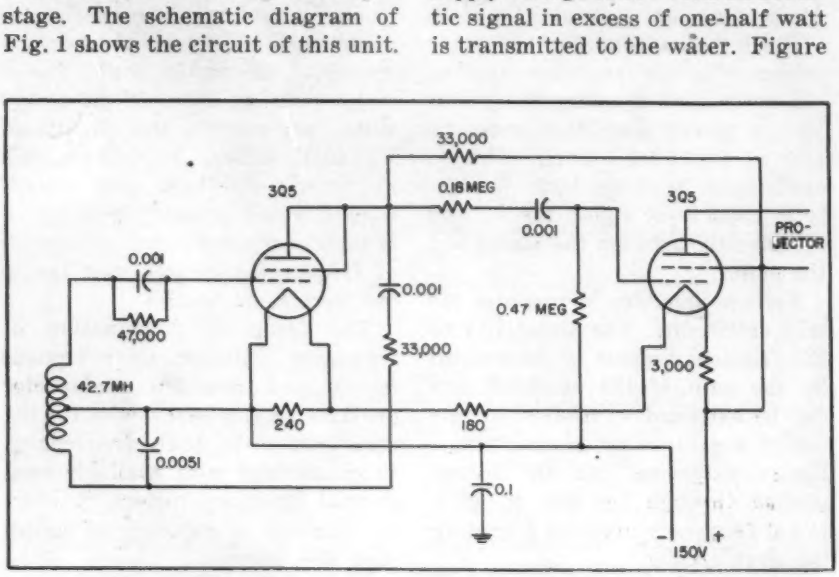



FIG. 1—Circuit of oscillator and amplifier that drives the magnetostriction transducer in the torpedo

The supersonic sound projector is mounted inside the torpedo by means of a mounting ring which is cylindrically curved on the bottom and is brazed, silver soldered, or welded to the inside surface of the torpedo shell. The projector is clamped into the mounting ring until the projector diaphragm makes proper contact with a rubber pad between the diaphragm and the shell surface. The active element of the transducer is a magnetostrictive nickel tube mounted on a small metal button, the diaphragm, which is joined to the case of the projector by a thin section of metal.

### Transducer Construction

A coil of several hundred turns surrounds the nickel tube and a small permanent magnet rod is placed inside and along the axis of the tube, in order to provide mag-

the poles of the magnet, and each successive turn is wrapped adjacent to the preceding one. Thus, the last turn appears around the pole of the magnet on the side of the coil opposite the one from which it started.

The three coils are connected in series aiding, and all three magnets are placed with like poles pointing in the same direction. The coil assembly is slipped inside the nickel tube to which a cap and rubber gaskets are fitted at each end to provide water tight joints. The caps are held together by six struts. The electrical cable is brought out through a gland providing a water-seal.

Figure 3 is a photograph of the listening hydrophone in its streamlined Lucite housing. The streamlining is required so that search may be conducted while the vessel is in motion. Several holes are drilled in the housing to make it free flooding.

### Reflector Details

To limit the sensitivity of the hydrophone to one direction for use as a direction indicator, it is equipped with a pressure-release reflector. This consists of a semicylindrical sheet of ⅛-inch Celltite Neoprene, which covers one-half the cylindrical tube at one time. The characteristics of the hydrophone are such that at a frequency of 24.5 kilocycles (the frequency of the projector), signals striking the concave surface of this reflector are focused along the axis of the hydrophone. Use of the reflector accordingly results in reducing the back response far below that of the front side; and increasing the level of the front response by virtue of the focusing effect.

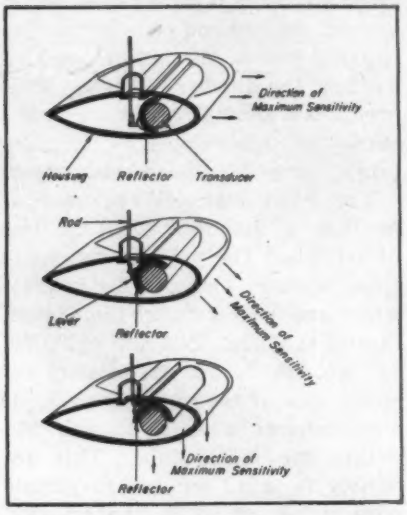



FIG. 4—The rod and lever mechanism rotates a reflector for training the listening hydrophone in depth

Figure 4 illustrates a rod and lever system that is used to change the direction of maximum sensitivity by rotating the reflector through 90 degrees about a longitudinal axis. This permits of horizontal search when the reflector is as shown at the top of Fig. 4, and vertical search when it is as shown at the bottom. The rod which controls the reflector extends up through the center of a supporting pipe to the deck of the search vessel.

### Performance Characteristics

The magnetostriction listening hydrophone has a peak sensitivity of about −80 db volts per dyne/cm², which is nearly constant (about five-db variation) from 15 to 35 kilocycles when used in conjunction with a matching transformer.

The azimuthal pattern for this unit is shown in Fig. 5. The minor lobes are nearly 20 db below the principal beam, while the front-to-back discrimination is about 30 db. The pattern is much broader in a plane perpendicular to the long axis of the hydrophone. In fact, it is practically nondirectional when used without a reflector. When used with the reflector, as previously noted, the back lobe is reduced about 30 db.

### Receiver Circuit

To realize the maximum capabilities of the transmitting system located in a lost torpedo, satisfactory receiving equipment had to be devised. Water background noise on a moving boat limits the maximum usable sensitivity.

The diagram of the listening receiver is shown in Fig. 6. The first stage is an untuned very low-frequency amplifier which is followed by a tuned vlf amplifier, and converter. The local oscillator injects a signal to the converter which, when mixed with the incoming vlf signal, produces an audible beat-frequency output. Tuning of the

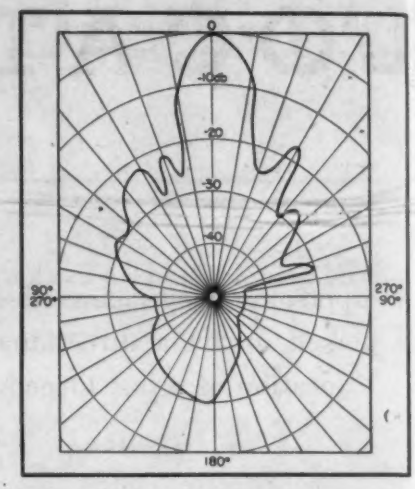



FIG. 5—Azimuthal pattern of magnetostriction listening hydrophone when mounted in its housing

local oscillator and vlf tuned circuits is ganged to produce proper tracking between the two frequencies over the tuning range of 21 to 51 kilocycles. The difference in frequency between the local oscillator and input signal is 1,500 cycles, and the audio resonant filter is adjusted to that frequency. If necessary, the audio filter consisting of $C_1$ and $L_1$ may be switched into the circuit to improve signal-to-noise ratio. The 6V6 output stage provides appreciable audio power which may be applied to the loudspeaker or may be picked up on headphones.

A level indicator is bridged across the output system, and use of this meter enhances the accuracy of bearing determinations. In addition, the rapid drop of level after the searching vessel has passed directly over a torpedo is immediately obvious, both visually and aurally.

A master gain control varies the gain of the first r-f stage, while auxiliary gain control in the a-f system permits the user of headphones to select his own desired operating level independent of the level of loudspeaker operation.

### Search Procedure

The listening hydrophone is attached to a long pipe which is installed in a steel well, approximately 18 inches square and standing about 2 feet above the cabin deck, located amidships on the starboard side of the keel. The hydrophone is drawn up in the well when not in use, and

lowered to a point about three feet below the keel when in use. Leads from the hydrophone are brought up through the tube to the listening receiver. The hydrophone is rotatable through 360 degrees. Overside training gear was installed on some vessels.

When search is begun, the frequency control of the receiving oscillator-amplifier is locked at the frequency of the torpedo's projector, and the gain control is set at a high level. The audible tone from the speaker is usually depended upon to give the first indication that the projector signal is being picked up, although with very weak signals it is necessary to use headphones.

### Search

When the projector signal is heard, the search boat is steered on the bearing specified by the indicator on the training gear, which points in the direction of the major lobe of the listening hydrophone. During the approach, the oscillator-amplifier meter is used instead of the audible note to indicate the direction from which the signal strength is a maximum and the course is corrected as required in order to maintain the highest possible meter reading. It is necessary, of course, to reduce the gain from time to time to prevent the meter needle from going off scale. If this procedure is followed, the searching boat will pass directly over the lost torpedo. This preliminary search is done with the hydrophone reflector in the azimuthal-searching position.

As soon as the course of the searching boat has been definitely established, the training gear is rotated through 90 degrees and the reflector changed to the depth-searching position. This means that the long axis of the hydrophone is now parallel to the course of the vessel, so that the reception beam is narrow in the direction the vessel is moving. When the signal reaches a maximum, the vessel should be directly over the lost torpedo, and a marker buoy.

The next step is for a diver to descend to the bottom and seek to locate the torpedo exactly. Under conditions of zero visibility, even the small area involved may still leave the diver a long and tedious search problem.

Experiments have been carried out in which the diver carries either in his hand or attached to his belt a listening hydrophone whose cable is attached to the diver's lines and connected to a standard listening amplifier on the deck of the diving boat.

The hydrophone is held with its axis horizontal and the main sound lobe pointed the way the diver is facing. He is instructed by his helmet telephone to turn himself about slowly while the operator in the boat watches the meter on the panel of the listening receiver. In this manner, the orientation of the diver for maximum signal reception is determined and he is instructed to walk straight ahead.

The orientation process can be repeated if either the diver or the operator suspects a deviation, or if the signal drops rapidly, indicating that the diver has passed the torpedo. This method has had startling success in several instances when the torpedo has been found by the diver's stumbling over it as he walked up the sound beam.

The acoustic locating system described, or similar systems, effected an enormous saving for the Navy in locating lost torpedos. The boat-equipped system has accounted for the recovery of over 250 electric torpedoes, and over 175 steam torpedoes. The same amplifier used with a diver's hydrophone accounted for over 60 additional electric torpedoes, and over 95 additional steam torpedoes. These recoveries represented a saving to the Government of over $4,000,000.


### Acknowledgments

This work was started at the Harvard Underwater Sound Laboratory under OSRD Contract OEMsr-287 by a number of scientists and technicians. Most of this group were transferred later to the Ordnance Research Laboratory at The Pennsylvania State College where the work is being continued. The work reported is the result of a group effort and not of one or two men. No one is singled out for special commendation. The authors' contribution lies principally in the writing of this report. This paper was cleared for publication by the Navy Department.

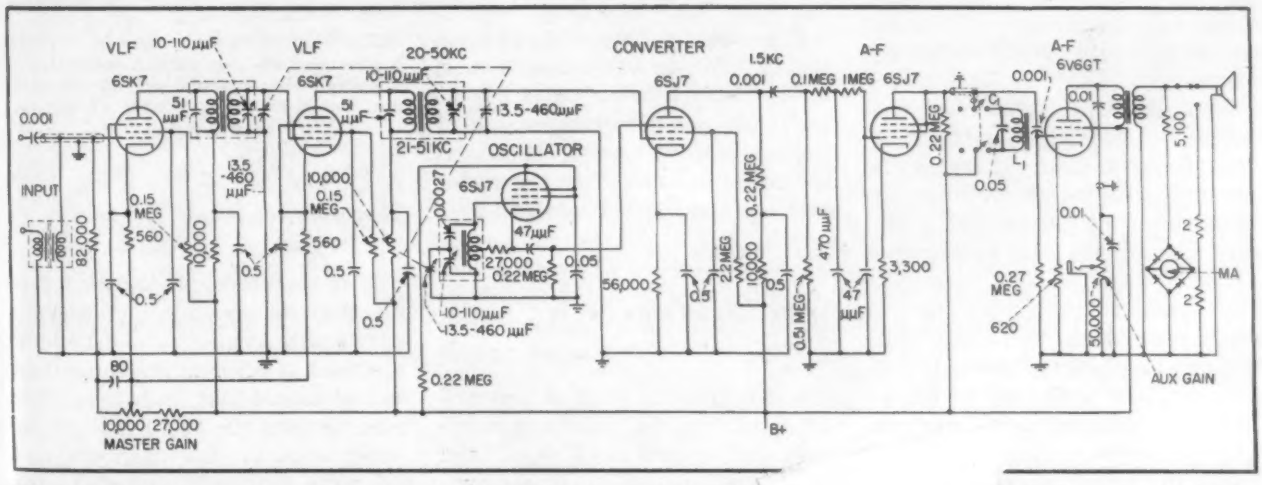
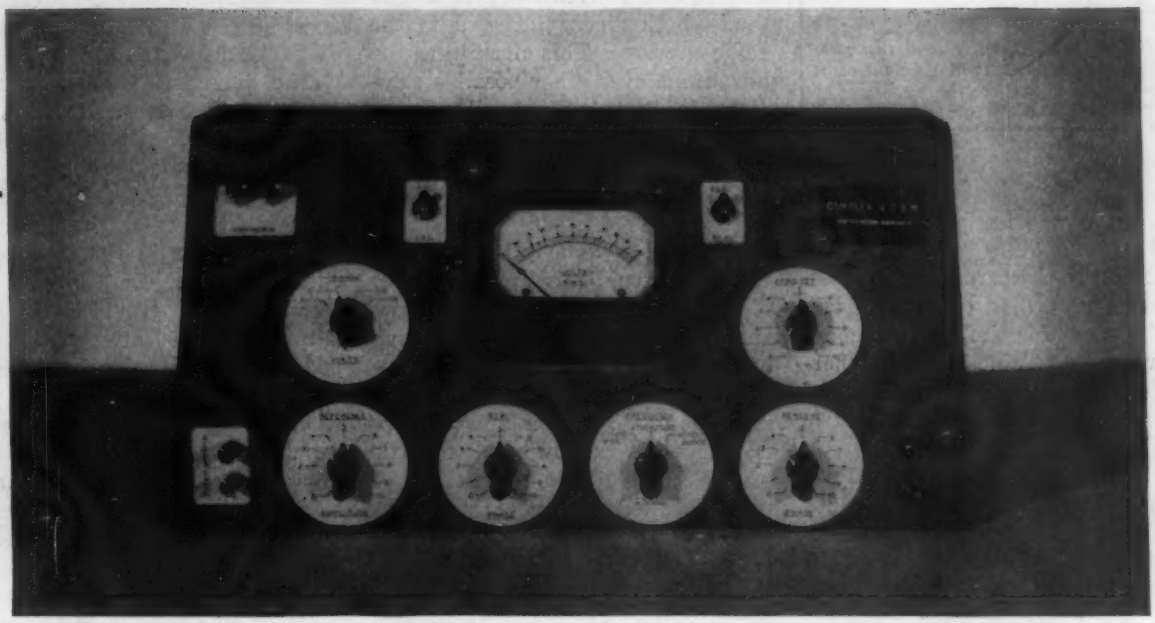




FIG. 6—Heterodyne circuit used for receiving 24.5-kilocycle signal from the t... both visual and aural indication are provided

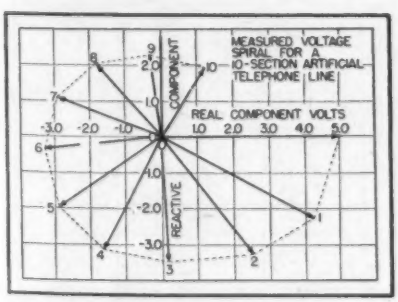
# of Voltage



Complex vacuum-tube voltmeter simplifies study of phase and angle of voltages in audio-frequency circuits

In a similar manner, if the reference voltage is advanced in phase by exactly 90 degrees, then the indication of the instrument will be the imaginary component of the unknown with respect to the original reference axis.

The block diagram of a system which will perform as indicated by the preceding is shown in Fig. 1. The reference voltage $e_r$ is fed into an amplifier to make the resultant amplitude large in comparison to $e_x$. The amplified reference is applied to a phase-shift circuit which allows the output voltage to be either in phase, or in leading quadrature with respect to $e_r$, thus providing for measurement of both $e_r$ and $e_j$. Output of the phase-shift network is applied to rectifier No. 1, producing at its output terminals a d-c voltage proportional to the magnitude of the amplified reference.




Angle and amplitude of voltages across sections of an artificial transmission line can be quickly determined using the complex voltmeter

The unknown voltage is applied (through a cathode follower) in series with the output of the phase-shift network to the input of rectifier No. 2. At the output of this rectifier there appears, therefore, a d-c voltage proportional to the vector sum of the unknown and the amplified reference. The outputs of the two rectifiers are connected in series opposition to a d-c vacuum-tube voltmeter which therefore measures the voltage component desired. Multiple range can be obtained through a voltage divider in the $e_x$ input circuit.

### Inherent Error

If the reference voltage has an amplitude of 50 volts and the amplitude of the unknown is limited to a maximum of one volt, then the inherent error of this method for various assumed phase angles can be determined as follows

$$e_r = 50 + j0$$
$$e_x = e_r + je_j \text{ where } (e_r^2 + e_j^2)^{1/2} = 1.0$$

If we let $e_r$ have the values given in the Table I, the true value of $e_j$ can be computed from

$$e_j = [(1.0)^2 - e_r^2]^{1/2}$$

The magnitude of the vector sum will be

$$|e_i| = [(e_r + 50)^2 + e_j^2]^{1/2}$$

Therefore the measured values of $e_r$ and $e_j$ will be

# Measuring Complex Components

**Real and imaginary components of unknown voltage are directly indicated in sign and magnitude relative to reference voltage by audio-frequency vacuum-tube voltmeter. Instrument simplifies measurements on amplifiers and filters. Operation is described**


**By GEORGE E. PIHL**

*Assistant Professor of Electrical Engineering*
*Northeastern University*
*Boston, Massachusetts*

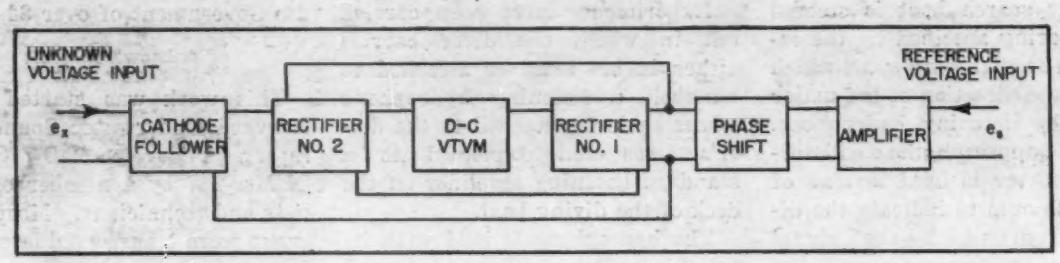




**FIG. 1—Block diagram of meter for indicating real and imaginary components of a complex voltage**

THE INSTRUMENT discussed in this paper is a vacuum-tube voltmeter that indicates directly the real and imaginary components of an unknown voltage, in terms of a reference voltage. The voltmeter has full-scale ranges of 1, 5, 10, and 50 volts and the frequency range extends throughout the audio spectrum, 20 to 20,000 cycles per second.

There has long been a need, particularly in the field of communications, for an instrument that would measure unknown alternating voltage in terms of its real and imaginary components, with respect to a second voltage used as reference. This need is especially true in measurements on filters, attenuators, and amplifiers where a knowledge of phase shift may be important. The instrument will perform such measurement at any frequency within the audio range. Its operation is based upon the well known fact that the magnitude of the vector sum of a large voltage and a small voltage is very nearly equal to the sum of the large voltage and the in-phase component of the small voltage.

### Basic Method

Let $e_s$ be a voltage of large magnitude used as reference. Let $e_r$ and $e_j$ be the magnitudes of the real and imaginary components of the unknown voltage $e_x$. If we put $e_s$ on the real axis, then the vector sum $e_t$ of the two voltages will be

$$e_t = e_s + e_x$$
$$e_t = e_s + e_r + je_j$$

The magnitude of $e_t$ is

$$|e_t| = [(e_s + e_r)^2 + (e_j)^2]^{1/2}$$

If $e_s$ is sufficiently large in comparison to $e_j$, then $(e_j)^2$ becomes negligible with respect to $(e_s + e_r)^2$ and the magnitude of $e_t$ is approximately

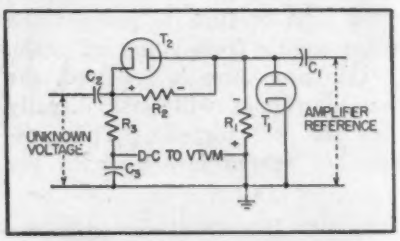



**FIG. 2—Reference and unknown voltages are rectified and combined. Combination is effectively the algebraic sum of reference and the in-phase component of the unknown voltage**

$$|e_t| = [(e_s + e_r)^2]^{1/2} = e_s + e_r$$

Therefore, $e_r$ is approximately

$$e_r = |e_t| - e_s$$

It is therefore possible to measure the real component of the unknown with respect to a large voltage used as reference by providing an instrument that reads the difference between the magnitude of the vector sum of the unknown and reference and the magnitude of the reference alone.

triode. The first section provides low output impedance for working into the phase-shift network controlled by $S_3$ and $R_2$. This network, when properly set, provides a leading phase shift of approximately 45 degrees.

The second section of $T_3$ works into two phase-shift networks, one controlled by $R_3$ and $S_5$ providing a lagging phase shift of approximately 45 degrees and its output providing the reference for measuring $e_r$. The other network out of $T_3$ controlled by $S_4$ and $R_4$ provides an additional shift of approximately 45 degrees leading for the measurement of $e_j$. The proper reference for the component to be measured is selected by $S_3$ and applied to $T_4$, the voltage amplifier which then works into the rectifier system.

In all three of the phase-shift networks, the proper capacitance depends upon the frequency only. Therefore $S_1$, $S_2$, and $S_3$ are ganged together and labelled as a frequency control, to be set for the frequency range desired. Potentiometers $R_2$ and $R_3$ are ganged together and used as the phase control for the real component. The setting which gives in-phase reference results in the lead and lag 45-degree shifts mentioned above. After this control is set, the control for measuring the imaginary component, $R_4$, is set for an additional 45 degrees.

Potentiometer $R_5$ is simply the zero set for the d-c vacuum-tube voltmeter. Voltage regulator tubes insure stable operation.

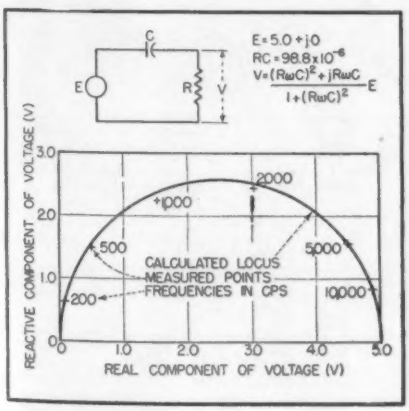



FIG. 4—Comparison of calculated and measured voltages shows utility of meter

### Controls and Method of Setting

The following is a summary of all controls:

RANGE: Ranges of 1, 5, 10, and 50 volts full scale plus or minus are provided.

ZERO SET: With USE-CAL switch on USE, reference voltage applied, and unknown terminals shorted, this control is set for zero voltmeter indication. With the switch in the USE position, $R_7$ having a resistance of 9,500 ohms is used as the voltmeter multiplier. This multiplier gives the input to $T_3$ a sensitivity of two volts. However, the microammeter scale has been altered to give a center zero, and the needle is adjusted to this point by $R_5$, the ZERO SET control. The ZERO SET applies about one volt to the grid of the second section of $T_3$ by this adjustment. Thus the actual range of the input to $T_3$ is $\pm 1$ volt.

REFERENCE AMPLITUDE: With USE-CAL switch on CAL, this control is adjusted for a voltmeter reading of 50 volts. Resistor $R_6$ of 0.5 meg gives the meter a full scale range of 100 volts, therefore the adjustment is made for center scale. Because $R_7$ has been previously set to give about one volt deflection, this voltage produces negligible deflection with the new multiplier in the circuit. The microammeter is therefore at its extreme left or zero-current position with no input voltage. The 50-volt point is therefore center scale which is marked zero on the microammeter face.

FREQUENCY: This control must be set to the appropriate range. The ranges provided are 20 to 200, 200 to 2,000, and 2,000 to 20,000 cps.

REAL PHASE: With $S_3$ on REAL, and an external lead used to connect the reference voltage to both the reference and the unknown terminals, this control is set for a maximum value as indicated by the vtvm.

REACTIVE PHASE: With $S_3$ on REAC, and an external connection as above, this control is set for zero value as indicated by the vtvm. This adjustment assures a reading of zero for the imaginary component of a pure real unknown and minimizes the inherent error of the method discussed previously.

**Table II—Calculated and measured phase shift of an R-C circuit**

| Calculated Values | | Measured Values | | Operating Frequency |
|---|---|---|---|---|
| $e_r$ | $e_j$ | $e_r$ | $e_j$ | In cps |
| 0.07 | 0.61 | 0.10 | 0.60 | 200 |
| 0.44 | 1.42 | 0.50 | 1.45 | 500 |
| 1.39 | 2.24 | 1.50 | 2.20 | 1,000 |
| 3.03 | 2.44 | 3.05 | 2.40 | 2,000 |
| 4.53 | 1.46 | 4.60 | 1.50 | 5,000 |
| 4.87 | 0.78 | 4.90 | 0.80 | 10,000 |

See Fig. 4 for circuit and equation

Although there may seem to be a large number of controls to be set, these do not have to be disturbed after they are once set providing the frequency is not changed. Therefore in the analysis of a complicated circuit at a single frequency, the operation is very simple, only the REAL-REAC switch and the RANGE switch being used.

For example, the complete voltage spiral of a twenty-section artificial telephone line may be obtained in about 15 minutes. On the other hand, if the frequency response characteristic of a network is desired, in general all of the above controls need to be reset at each new frequency. While this resetting slows down the procedure, the method is faster than others.

The agreement between measured and calculated results for the voltage across the resistance in a simple R-C circuit, as a function of frequency, is given by tabulated values in Table II and the curve in Fig. 4. Input voltage was maintained at five volts and was used as the reference.

The instrument described has been in service for a considerable period and has proved itself to be stable in operation and reliable in indication. It represents what is believed to be the first instrument that reads directly the complex value of a voltage in the rectangular coordinate system and establishing polarities of the real and imaginary components as well as their magnitudes. Its limitations are similar to those for any electronic measuring instrument, namely that controls must be set with care and voltages under measurement must be of good sinusoidal waveform and reasonably good frequency stability.

**Table I—Comparison of true and measured values of voltage**

| Value of either the real or the imaginary components | | | |
|---|---|---|---|
| True | Measured | True | Measured |
| 0.00 | 0.01 | 0.60 | 0.61 |
| 0.10 | 0.11 | 0.70 | 0.70 |
| 0.20 | 0.21 | 0.80 | 0.80 |
| 0.30 | 0.31 | 0.90 | 0.90 |
| 0.40 | 0.41 | 1.00 | 1.00 |
| 0.50 | 0.51 | | |

Measured values are tabulated to two decimal places to correspond with the precision of indicating instrument used in actual circuit.

$$e_r = [(e_r + 50)^2 + e_j^2]^{1/2} \doteq 50$$
$$e_j = [e_r^2 + (50 + e_j)^2]^{1/2} - 50$$

Obviously the error in the measurement of either component will be the same for the same component value. As Table I shows, inherent error due to the method of measurement is not serious because the maximum error of 0.01 volts is only one percent of full scale. Furthermore, it is possible to reduce this error in the actual operation of the instrument as will be explained later.

### Rectifier Circuits

Because the method of operation of this instrument is based upon the measurement of a small voltage difference between two large voltages, it is apparent that the two rectifier circuits must have characteristics as nearly identical as possible. This condition is not difficult to satisfy as each rectifier is operating linearly because the applied a-c voltages are large. In addition, although the voltage applied to rectifier No. 2 is a variable, depending upon $e_x$, the variation is never greater than two percent under all conditions. Because both rectifiers operate linearly, a simple zero set control can be provided in the d-c vacuum-tube voltmeter circuit to take care of slight unbalance of the rectifier circuits which may develop as the frequency is varied.

It is evident from the foregoing that the heart of the instrument is the rectifier system. The circuit diagram of Fig. 2 satisfies all of the requirements. In this circuit the amplified reference is rectified by $T_1$ acting as a linear peak diode, the resulting d-c voltage appearing across $R_1$ with the polarity indicated. The vector sum of the unknown and amplified reference is applied to $T_2$ also acting as a linear peak diode, the resulting d-c voltage appearing across $R_2$. The difference of these two d-c voltages then appears across $C_3$ as is evident from the above connections. Diodes $T_1$ and $T_2$ may conveniently be a dual diode, both diodes included in the same envelope. This circuit has the advantage over other possible solutions in that both signal sources and the vtvm have a common low potential or ground side.

### Phase Shift Networks

From the description of the method given, it is apparent that if the reference is a source of low voltage, it must be amplified before being applied to the rectifier system. Furthermore, for the measurement of $e_r$, the amplified reference must be exactly in phase with $e_x$ and for the measurement of $e_j$ the amplified reference must be exactly 90 degrees leading with respect to $e_r$. Because some phase shift within the amplifier is inevitable over an extended frequency range, two phase-shift controls are necessary. One is provided to secure the in-phase reference, the other for the 90-degree reference.

The reference is first shifted approximately 45 degrees in a leading direction by a resistance-capacitance circuit. The phase control for the measurement of $e_r$ consists of a resistance-capacitance network to shift the phase in a lagging direction so that the net phase shift is zero. The phase control for the measurement of $e_j$ consists of another resistance-capacitance network to shift the phase an additional amount over the original 45 degrees so that the net phase shift is 90 degrees.

### Complete Circuit

The diagram of the instrument is shown in Fig. 3. Tube $T_1$ is a double triode, each section being used as a cathode follower. The first section provides a means of changing the voltage range by the voltage divider in the cathode circuit. Range is selected by $S_1$. The second section provides a divided output voltage at constant impedance for introduction into the rectifier system.

Tube $T_2$ is the double rectifier which works into the d-c vacuum tube voltmeter, $T_3$. The latter has a range of plus or minus one volt, center zero. The switch $S_2$ provides a means of opening one rectifier circuit in order to set the magnitude of the amplified reference voltage at 50 volts, allowing it to be read by the same vtvm because $S_2$ also changes vtvm range from one volt to 100 volts. The magnitude of the reference is controlled by $R_1$.

The reference is applied to the first section of $T_3$, another double

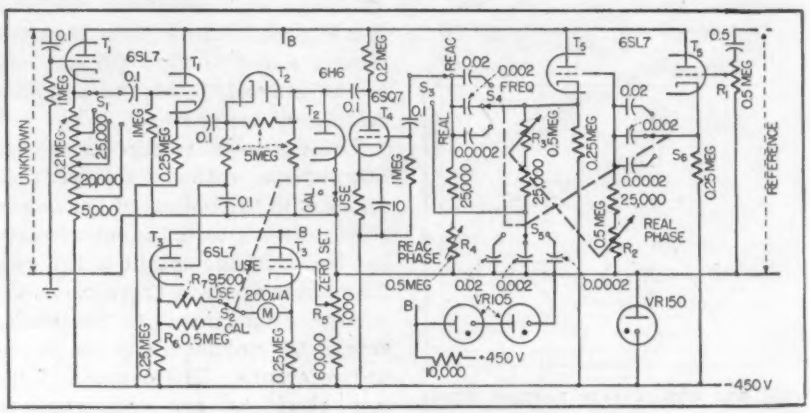



FIG. 3—Complete circuit diagram of the complex voltmeter indicates use of cathode followers to feed vacuum tube voltmeter

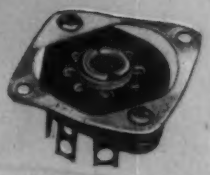
# Airborne Radar Specifications

BECAUSE of an interest expressed by numerous readers, ELECTRONICS publishes the following table of radar technical specifications as an addendum to the data appearing in the November 1945 issue.

A Presidential directive, issued since compilation of this information, makes the Office of Technical Services, Department of Commerce, Washington 25, D. C., the official source for all information relating to declassified Army and Navy manuals. As the tremendous task of listing and numbering OSRD, Radiation Laboratory, Service, Intelligence and other reports goes forward, the titles, identifying numbers and brief summaries are published in weekly issues of a running bibliography. Subscriptions to this publication are sold by the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at an initial yearly charge of $10. The reports are available on microfilm or in photostat form.

**TECHNICAL DETAILS OF RADAR SETS RECENTLY DECLASSIFIED BY THE ARMY AIR FORCES AND SIGNAL CORPS**

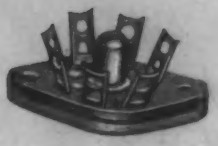
| Type Number | AN/APS-10 | AN/APS-15 | AN/APG-5 | AN/APG-13 | SCR 717-1 | SCR-720-A,-B, -C,-D | SCR 520-A | SCR 517-C | AN/APQ-7 |
|---|---|---|---|---|---|---|---|---|---|
| Primary Function | Airborne search with beacon functions | Airborne search, bombing and navigation by beacon | Range only for gun turrets | Range for forward-firing cannon | Airborne surface search with beacon functions. Similar in purpose to SCR 517-B | Air search with beacon function. Similar in purpose to SCR-520-A,-B | Air Search (See SCR-720-A) | Airborne surface search. Also used on small craft | High resolution for blind bombing; also as altimeter and navigational aid |
| Size, Weight (Pounds) | Air Transportable—100 | Air Transportable—349 | Air Transportable—95 | Air transportable—113 | Air transportable—373 | Air transportable—415 | Air transportable—477 | Air transportable—401 | Air Transportable—775 |
| Carrier Frequency (mc) | 10,000 | 9,375 | 2,500 | 2,800 | 3,300 | 3,000 | 3,000 | 3,000 | 10,000 |
| Wavelength ($\lambda$) (cm) | 3 | 3.2 | 12 | 10.7 | 9.1 | 10 | 10 | 10 | 3 |
| Peak Power (Pt) (kw) | 8 | 40 | 0.5 | 1.5 | 150 | 150 | 60 | 60 | 50 |
| Pulse Width (d) (microseconds) | 0.8 | 1 (Beacon, 2) | 0.7 | 0.7 | 1.125 | 0.75 | 1 | 1 (Beacon, 2.5) | 1, 1, 0.4 (Beacon, 20) |
| Pulse Rate (fr) (pps) | 800 | 650 | 1,200 | 1,200 | 750 (Beacon, 375) | 1,500 (Beacon, 375) | 2,000 (for 100 mile range, 400) | 400 | 400, 800, 1,600 (Beacon, 400) |
| Radiator Type, Size Gain (Go) | dipole; 18 in. paraboloid modified for $csc^2$ coverage below horizontal 700 | Cutler feed to 29-in. paraboloid modified for $csc^2$ to 70 deg 200 | 22 in. 18-element end-fire or 12-in. paraboloid. 25-40 | End-fire array 35 | Horizontal dipole in 29-in. parabola 340 | Dipole in 29-in. parabola 340 | Vertical dipole in 30-in. paraboloid 540 | Dipole with 29-in. parabola 340 | Variable-width wave guide feeding dipole array in 16-foot scanner 1,500 |
| Types of Scan | Circular Tilt—18 and + 3 deg | Circular Tilt ± 20 deg | Range search out to 1,800 or 3,600 yd | not for search | Circular Tilt + 10 to −45 deg | Circular Four types of tilt | Circular (180 deg search) Tilts at 30 deg a second | Circular (180 deg search) Tilts + 5 to −30 deg | Sector ± 30 deg |
| Beam Width (b) (degrees) | 5 | 3 | 28 | 28 | 9 | 10 | 10 | 10 | 0.4 Azimuth 30 Elevation |
| Horizontal Scanning Rate (rpm) | – | 12 or 24 | – | – | 20 | 360 | 360 | 60 | 90 |
| Receiver Noise (n) (db above $kt\Delta f$) | 15 | 18 | 13 | – | 11-15 | 11-15 | – | 19-21 | 15 |
| Receiver Bandwidth ($\Delta f$) (mc) | 6 | 2.5 | 8 | 1.9 | – | 3 | – | 4 | 4 |
| Indicators | 1 or 2 PPI | 1 type PPI 1 type A | Pilot light and linkage to computer | 1 type A with step marker | 2 type PPI | 1 or 2 type B with 2 or 1 type C | – | 1 type B Elevation meter | 2 type PPI 1 type A |
| Maximum Range (r max) at 1,000 Foot Altitude, or as otherwise noted (miles) | 55 | – | (bombers at 10,000 feet) 2 | – | – | 5 to 10 | – | (bombers at 10,000 feet) 5.7 | Mounted on fighters 100 |
| Minimum Range (yd) | 400 | 200 | – | 300 | 200 | 100-250 | – | 125 | – |
| Range Accuracy (yd) | ± 2 percent | ± 1 percent | 40 | ± 30. | ± 5 percent | ± 10 percent | – | ± 10 percent | – |
| Angular Accuracy (degrees) | 2 | 3 | – | – | ± 3 | ± 5 | ± 3 | ± 3 | – |
| Additional information | Radar and beacon have AFC and require no manual tuning | Precision long-range beacon delay in 10 mile steps | Range unit locks on nearest target in line with guns | Operator tracks target manually | Can supply video signal to bombsight equipment | C-tube shows only targets within limits of range-dial setting | Beacon operation at 10 and 100 miles | Beacon ranges at 25 and 100 miles | PPI shows true ground range instead of slant range. Computer produces slant rangemarker at release point. |



No. 2559

No. 56A12533

No. 56B12534



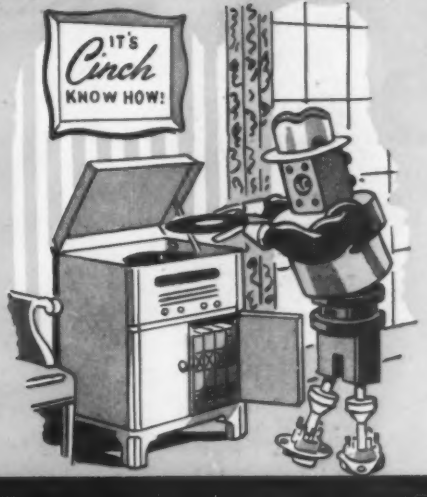
No. 56B12535

No. 2541

No. 2543

CINCH laminated miniature sockets extensively and constantly serve communication requirements; radio sets, auto and home, television... Cinch the complete line, the standard socket. The sockets shown illustrate the large possible variety; center shield, shield plus ground strap, shock proof spring, finder ring eliminated and replaced with two full top plates, and double bottom plate construction; the variation extended with tropicalization or wax impregnation. Cinch "Know How" anticipates the future needs, adequately serves the present requirements. Cinch laminated miniature socket is the standard. Write for samples.

# Cinch

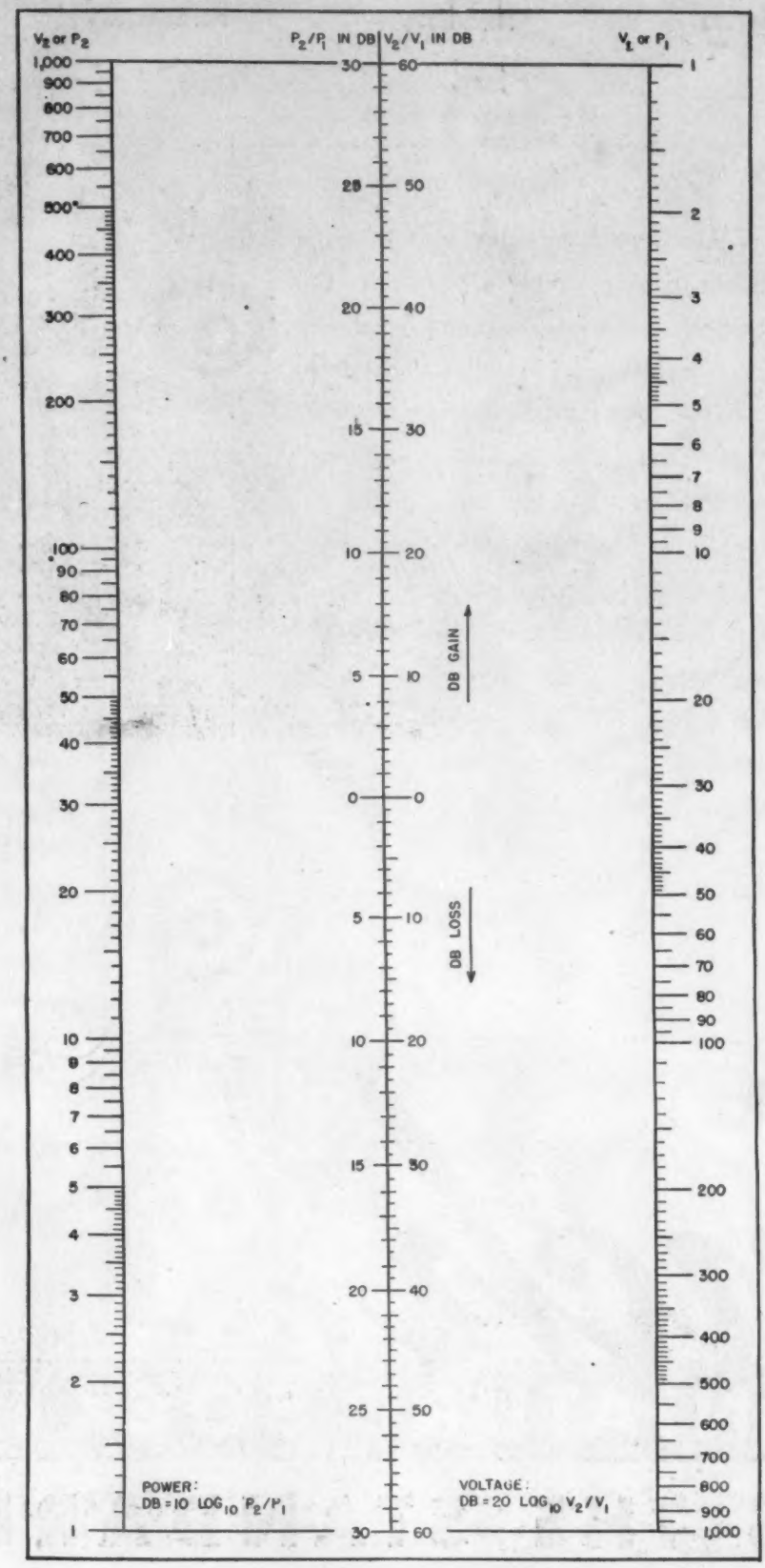



## MINIATURE SOCKET

## IS THE STANDARD

CINCH MFG. CORPORATION, 2335 W. Van Buren St., Chicago 12, Ill., *Subsidiary of United-Carr Fastener Corp., Cambridge 42, Mass.*

# DB Gain-Loss Calculator




**By LLOYD A. LOHR**
*Vacuum Tube Development Section*
*Naval Research Laboratory*
*Washington, D. C.*

IN WORKING with communications equipment, it is often desirable to know the db gain or loss ratio of two voltages, currents, or powers with a minimum amount of calculation. This nomograph will give the db value directly for any voltage, current, or power ratio up to 1,000 to 1 with only one setting of a straightedge, and the range can readily be extended by using multiplying factors. The converse problem, of finding a ratio that will give a desired db gain or loss, can just as readily be solved.

If $V_1$ and $V_2$ are known, place the straightedge to connect their values on the outer scales and read voltage gain or loss in db on the right side of the center scale.

If $P_1$ and $P_2$ are known, place the straightedge to connect their values on the outer scales and read voltage gain or loss in db on the left side of the center scale.

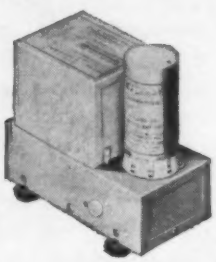
If the db value and one voltage or power value are known, connect these values with a straightedge and read the other voltage or power value on the third scale.

The range of the nomograph can be extended by applying a multiplier to one of the log scales and adding to the db scale values as follows:

| Multiplier for one log scale | Add to values on $P_2/P_1$ scale | Add to values on $V_2/V_1$ scale |
|---|---|---|
| 10 | 10 | 20 |
| 100 | 20 | 40 |
| 1,000 | 30 | 60 |
| 10,000 | 40 | 80 |
| 100,000 | 50 | 100 |

*Example*: What is the db gain for a voltage ratio of 100 to 5? From the nomograph, the db gain is approximately 26.1 db. Checking, db = 20 log $V_2/V_1$ = 20 log 20 = 26.06 db.

# Save Space . . . Improve Efficiency with a MALLORY *Self-Rectifying* VIBRATOR



**MALLORY VIBRAPACK***

**Mallory Vibrapacks deliver voltages from 125 to 400 from low voltage sources . . . with high efficiency, low battery drain, ease of installation, long life.**

**Reg. U. S. Pat. Off. for vibrator power supplies.*

If you're a manufacturer of automobile radios, mobile communication systems or of any other equipment using vibrator power supplies, now is the time to consider the Mallory *self-rectifying* vibrator.

Mallory self-rectifying vibrators are identical in size with the interrupter type. But—and here's the important point—they save space and wiring, and give you less components to worry about.

That's not the whole story either. You get top performance with Mallory self-rectifying vibrators. They assure high over-all power supply efficiency and eliminate the voltage drop within the rectifier tube plus the heater load.

Mallory engineers, who have produced more than 15,000,000 vibrators, invite your vibrator problems—will be glad to give you specific information about the self-rectifying type for your particular application. Write for copies of the comprehensive vibrator questionnaire.

***More Mallory Vibrators are in use today than all other makes combined***

P. R. MALLORY & CO. Inc.

**MALLORY VIBRATORS AND VIBRATOR POWER SUPPLIES**

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

# TUBES AT WORK

Edited by VIN ZELUFF


Guillotine Tuner for F-M..... 136
Radio Beams for Railroads..... 136
Airborne Television Telemetering..... 138
VHF Transmitter Power Measurements..... 158


## Guillotine Tuner for F-M

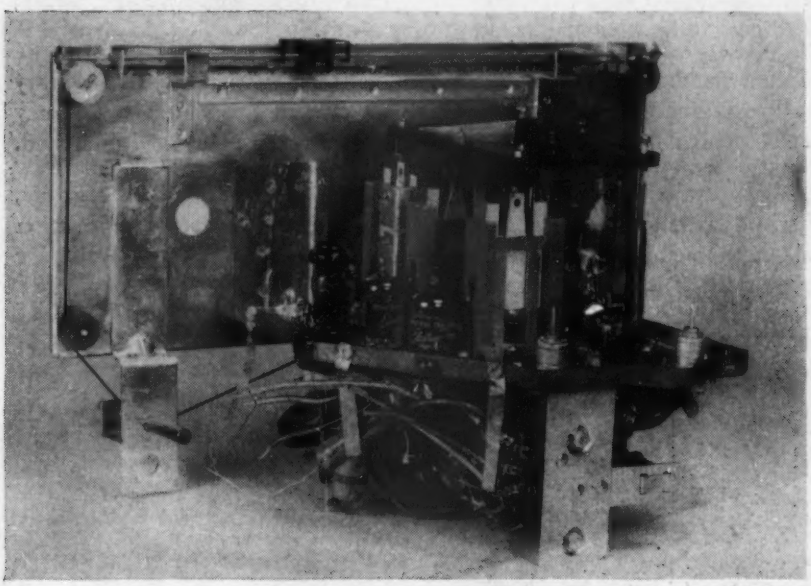
VARIABLE inductance tuning is one answer to the problems arising from the transfer of f-m stations to the higher frequencies. Such a system has been perfected by General Electric engineers.

Two identical silver-plated brass frames are used which, when connected at their open ends, form a two-turn inductance. Tuning is done by movement of a silver-plated brass blade between the turns. The inductance of each turn is reduced as is the mutual inductance between them. Slots in the blade provide a means of tracking the oscillator and r-f circuits.

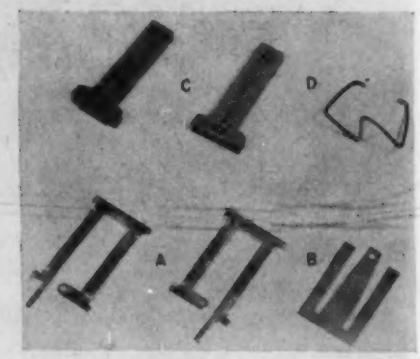
Because the tuner is entirely tool-made, precise production control of tracking is possible without high labor content in the cost of manufacture. Both terminals of the tuner project through the receiver chassis to provide a rugged tie point for soldered connections.

Nicknamed the "guillotine" tuner because of the sliding blade, the unit tunes both f-m bands and two or more short-wave spread bands in General Electric f-m receivers. Other ranges are tuned by adding shunt capacitance and fixed series inductance to the guillotine circuit. With the guillotine tuner it is possible to localize each tank circuit within a small area and to keep r-f chassis currents at a minimum. Since the blade of the guillotine is ungrounded, sliding contacts and pigtails are eliminated. Little trouble is had from regeneration or alignment difficulty.

Production assembly and testing of the tuners at the factory will be localized in a department set apart from the main chassis production line. Tuners will be assembled, tested and then transported to the chassis assembly lines in much the same manner as engines are handled in an automobile assembly plant. Only two types of front-end assemblies are used to tune eleven different models of General Electric f-m receivers.



Front end of a General Electric receiver containing the guillotine tuner




A two-turn inductance is formed by the two frames *A*, and tuning is done by the guillotine blade *B*, sliding in the grooves of two supports, both sides of which show at *C*. These support posts are held to the chassis by the clamp *D*

The complete tuner is enclosed in a metal box for shielding, and for mechanical protection and dust proofing. Microphonic howl when receiving short-wave stations is said to be completely absent.

In the receiver, a loop is used on all a-m bands but power line pick-up is used for local f-m reception. Terminals permit outdoor antennas to be used.

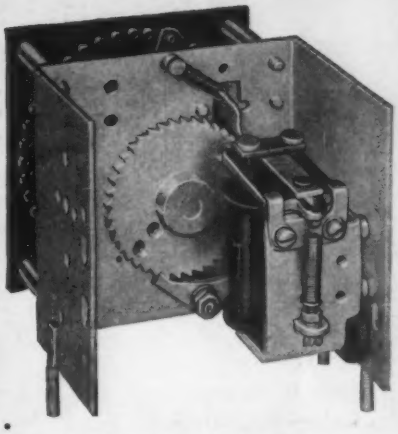
## Radio Beams for Railroads

BEAMED RADIO, wire, and cable circuits normally employed in carrying commercial messages may be utilized in emergencies to transmit electrical impulses to control railroad switches and signals.

In a recent test conducted at a signal control tower at Red Bank, Pa., the Pennsylvania Railroad employed a special linking of existing wire, cable, and beamed radio circuits extending from the control tower to Pittsburgh, Washington, D. C., Philadelphia, New York, and back to Pittsburgh and the tower.

Normally a centralized traffic control machine in Brady tower near Redbank controls the signaling between Red Bank and Oil City, (53 miles away), by the transmission of d-c pulses. These are arranged to have distinctive character for selecting the desired stations, switches, and signals over a pair of line wires extending throughout

# HUNDREDS OF CONTROL PROBLEMS SOLVED WITH STEPPING RELAYS



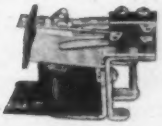
## GUARDIAN SERIES R

**1 Continuous Rotation**
In this type the contact finger advances one step each time the circuit is made and broken. Weight approximately 20½ ozs.

**2 Electrical Reset**
Resets when a second coil is energized. Weight approximately 23 ounces.

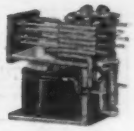
**3 Add and Subtract**
Steps back one or more contacts at a time instead of resetting completely. Weight approximately 28½ ounces.

**TYPICAL GUARDIAN UNITS AVAILABLE IN COMBINATION WITH GUARDIAN STEPPERS**

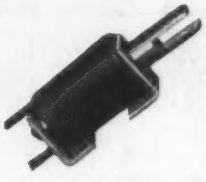


Series 100 Snap-Action Relay

Guardian Featherub Switch



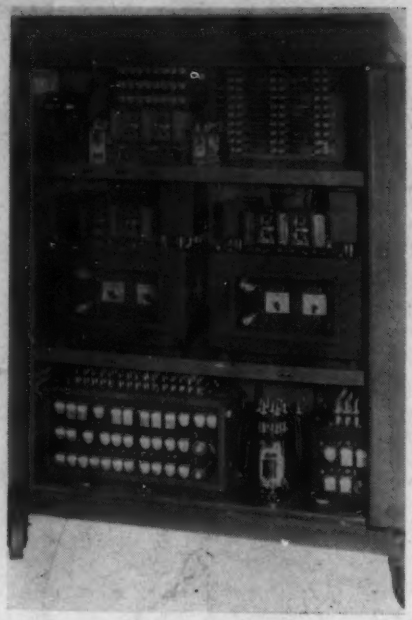
Series 500 Midget Relay



Series I-A Solenoid

**Design engineers are discovering new, efficient, money-saving applications daily for Guardian basic-type Stepping Relays. Typical applications include Automatic Sequence selection of circuits; Automatic Sequence cross connection of circuits; circuit control of Automatic Business Machines; control of Production Totalizing and Conveyor equipment; remote selection of records on Coin Operated Phonographs; Automatic Circuit Selection controlled from a pulsing dial; Automatic Wave Changing on short wave transmitters. This Guardian Stepping Relay is furnished for three basic types of A.C. and D.C. operation: Continuous Rotation—Electrical Reset—Add and Subtract. On each of these types the contact finger rotates in a counter-clockwise direction and all three types are designed to follow 10 pulses per second within the rated voltage range of the relay. Special construction prohibits skipping or improper indexing of the ratchet. Guardian Steppers may be furnished as separate units; in combination with relays, contact switches, solenoids, etc., completely assembled and wired to terminals; mounted on special bases or in enclosures. Any *standard* Guardian Stepping Relay can be modified to meet practically all "special" stepper control applications where quantities warrant special designing. For complete details write for Bulletin SR.**

**GUARDIAN ELECTRIC**
1625-B W. WALNUT STREET CHICAGO 12, ILLINOIS
A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY



**Some of the electronic equipment installed at Brady tower by Union Switch and Signal for the test**

the controlled territory from the tower. The operator controls trains while watching lights on a diagram.

The switches and signals have corresponding levers on the control machine which are positioned as desired. Operation of a code-starting button gives the pulses of long and short duration predetermined sequence to select the correct station along the railroad and to operate functional relays at this location. In the test demonstration these pulses were converted to carrier current pulses which were transmitted over a PRR telephone line from Brady tower to Pittsburgh using a frequency of 12.3 kc.

The control pulses were delivered to the Western Union office in Pittsburgh, then transmitted over Western Union carrier-telegraph circuits to Philadelphia by way of Washington. This carrier frequency system has all carrier frequencies below 30 kc, and as many as 36 independent multiplex telegraph messages can be transmitted in each direction simultaneously on a single pair of line wires. This would permit 144 telegraph operators to send messages simultaneously in one direction and a similar number in the opposite direction. In the demonstration, one multiplex telegraph channel was utilized for the transmission of the pulses while at the same time there may have been 140 telegraph messages on the same pair of wires traveling in the same direction. Repeater stations are placed along the line at intervals of about 150 miles.

*Microwave Link*

At Philadelphia, the control pulses modulated a microwave transmitter and were beamed toward New York City over the Western Union relay system using two intermediate repeater stations between Philadelphia and New York (ELECTRONICS, Dec. 1945, p 300).

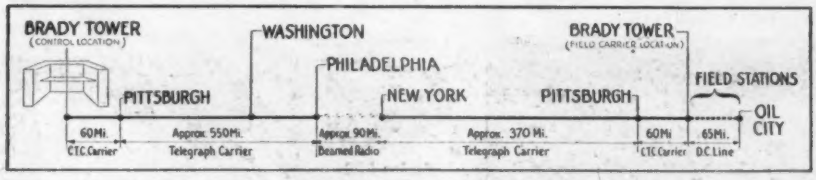
The radio beam can handle 256 multiplex telegraph circuits so 1,024 operators could transmit telegrams simultaneously in one direction. The control code would require the equivalent of only one telegraph channel so that 1,020 telegraph messages could be on the beam at the same time that a control code was being transmitted. The frequencies used between Philadelphia and New York are 3,970 and 4,120 megacycles.

The beamed pulses terminate at the Western Union building in New York. There the pulses are shifted to a carrier transmitted over Western Union lines from New York to Pittsburgh.

At Pittsburgh, Western Union receiving equipment operated Union Switch and Signal Company carrier equipment to send coded 25.4-kc pulses on to a field carrier location at Brady tower. Here a sharply tuned 25.4-kc receiving filter discriminates against other frequencies (two carrier frequencies, 12.3 and 25.4 kilocycles, are transmitted in opposite directions on the one line pair at the same time between Brady and Pittsburgh). After the 25.4-kilocycle pulses are amplified, they are fed through auxiliary apparatus which converts them to d-c pulses and places them on the code line extending to the switch and signal locations.

After a switch and signal respond to the control code, the circuits start an indication signal back to the control point to show what has transpired. This travels back over the same types of circuits.

The demonstration suggests the immediate possibility of use of radio as a standby communication channel to insure continuity of centralized traffic control operation in cases of line failure because of flood, hurricane, or storm, because there would be less possibility of interruption than with pole-carried line wires.




**The normal 65 miles of wire line used for traffic control between Brady Tower and Oil City were spread out to over 1,000 miles of carrier current and beamed radio circuits for the communication test**

## Airborne Television Telemetering

TELEVISION TELEMETERING enables observers at a ground station to see by television all instrument recordings and indicators of pressures, strains and structural failures of a test plane in the air. Thus, the pilot is freed from the necessity of keeping a constant check on his test instruments, and can devote his full attention to handling the plane.

To supply the need for a permanent record of test flights, all flight data shown on the television receiver screen on the ground is put on movie film. If serious failures result in the loss of a plane, these pictures, being filmed up to the moment of disintegration, can be studied to establish accurate reasons for the mishap.

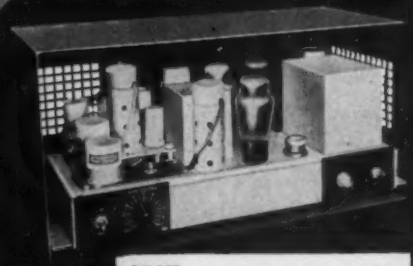
The system as developed for the Navy by engineers of Farnsworth and Curtiss-Wright consisted of a television theater and television transmitter in the plane and a mobile television receiving unit on the ground. This equipment trans-

(Continued on p 154)

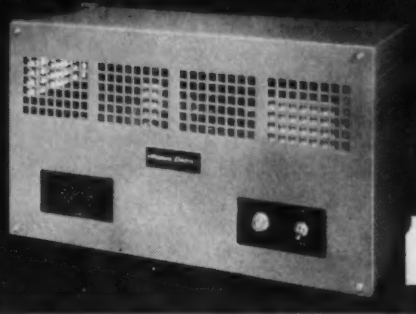
# PACKAGED FOR WIRED MUSIC

## 3 new Subscriber Amplifiers

**140A** single channel a-c—d-c amplifier.



**124H** two channel amplifier with selector switch.



**124J** single channel line level amplifier.

These three new amplifiers designed by Bell Telephone Laboratories are the first high quality packaged units ever made specifically for subscriber installations of wired music service.

The 124H and 124J are adaptations of the same general type used so successfully on network program distribution lines and in radio stations and public address systems. They differ only in that the 124H offers a microphone channel in addition to the line channel. The completely new 140A a-c—d-c amplifier, which is the *first* ever to offer the same stability with d-c operation as it does with a-c, can probably be used in 80% of your subscriber installations.

All three units can operate directly from telephone lines because they are equipped with a suitable input transformer. All may be used as fixed or portable equipment, and are suitable for rack or cabinet mounting.

For full information, call your local representative of the Graybar Electric Co., or write to Graybar, 420 Lexington Ave., New York 17, New York.

| | 124H | 124J | 140A |
|---|---|---|---|
| Frequency Response | ±1 db 50 to 10,000 cycles. | ±1 db 50 to 10,000 cycles. | ±1 db 50 to 10,000 cycles. |
| Maximum Gain | 63 db (line)<br>104 db (microphone) | 63 db | 60 db |
| Gain Control | Continuously variable. | Continuously variable. | Continuously variable. |
| Source Impedance | 37½, 150 or 600 ohms (line),<br>30 or 250 ohms (microphone). | 37½, 150 or 600 ohms. | 150 ohms,<br>600 ohms or bridging. |
| Load Impedance | 1 to 1,000 ohms. | 1 to 1,000 ohms. | (4 windings) 4, 8, 125,<br>125 ohms. |
| Signal to Noise Ratio | 77 db (line), 48 db<br>(microphone). | 77db | 60 db |
| Output Noise | —37 dbm (line),<br>—8 dbm (microphone). | —37 dbm | —20 dbm |
| Output Power | 12 watts 2% total harmonic distortion for nominal load impedance. 20 watts 5% harmonic distortion if reconnected and Western Electric tubes are used. | | 6 watts d-c, 10 watts a-c, less than 5% harmonic distortion. 5 watts d-c, 8 watts a-c, less than 2% harmonic distortion. 4 watts d-c, 6 watts a-c, less than 1% harmonic distortion. |
| Power Supply | 105-125 volts, 50-60 cycle a-c. | 105-125 volts, 50-60 cycle a-c. | 105-125 volts, a-c or d-c. |

**Western Electric**

**— QUALITY COUNTS —**

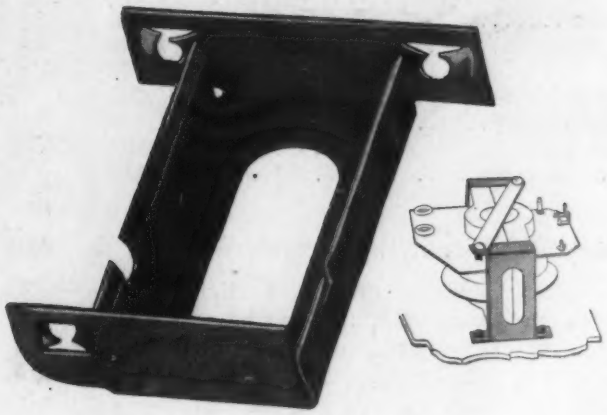
Western Electric

Distributed by Graybar

OFFICES IN 93 PRINCIPAL CITIES

# *This is a* SPEED NUT*.....

*and*



# THIS is also a Speed Nut*!

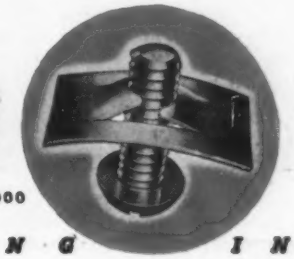
Of course you recognize the Standard SPEED NUT shown above, but just look at the "nightmare" our development engineers dreamed up, to provide multiple fastening and operational functions in a single unit! It is used in the assembly and mounting of television transformers (see sketch) and you can readily understand its advantages over special mounting brackets and individual, hard-to-handle threaded nuts and lock washers.

In addition to the widely-used standard types of SPEED NUTS, hundreds more are *functionally* designed to combine assembly operations, eliminate unnecessary handling of parts, speed-up production and thereby reduce final costs. They are fabricated on specially designed, automatic machines which produce *completely finished* parts at high speeds.

There must be some step in the assembly of your product where, by changing over to SPEED NUTS, your costs could be reduced and your product improved. Why not send us your assembly details, or better still, send in the parts involved. We will be glad to give you a complete fastening analysis . . . at no cost.

**TINNERMAN PRODUCTS, INC.**
**2106 FULTON ROAD • CLEVELAND 13, OHIO**

In Canada: Wallace Barnes Co., Ltd., Hamilton, Ont.
In England: Simmonds Aerocessories, Ltd., London
In France: Aerocessoires Simmonds, S. A., Paris
In Australia: Aerocessories, Pty., Ltd., Melbourne



**Speed Nuts*** PATENTED

MORE THAN 4000 SHAPES AND SIZES

*Trade Mark Reg. U. S. Pat. Off.

*FASTEST THING IN FASTENINGS*

# INDUSTRIAL CONTROL

Edited by VIN ZELUFF


**Automatic Recording Ultraviolet Photometer** ..... 140
**Electronic Drive for Printing Presses** ..... 176
**Simple Foolproof Production Tester** ..... 178
**Electronic Ignition System** ..... 184


## Automatic Recording Ultraviolet Photometer


BY IRVING M. KLOTZ AND MALCOLM DOLE

*Department of Chemistry, Northwestern University*
*Evanston, Illinois*


A RAPID and accurate method of gas analysis involving electronic equipment, amplifiers, photoelectric recorders and the like was developed at Northwestern University in connection with an OSRD sponsored research.

It became highly desirable to be able to follow concentrations of toxic gas in a moving air stream in the laboratory or at some particular point above ground in the open in order to study first, the effectiveness of activated charcoals in adsorbing toxic gases and second, the effectiveness of chemical warfare munitions in producing lethal concentrations when exploded under all kinds of meteorological and geographical conditions.

For analysis in the gaseous state, the property of certain gases to absorb ultraviolet light strongly can be used to detect two or three parts per million of the gas and to measure accurately greater concentrations. In our apparatus this measurement was accomplished by introducing a balanced double-phototube arrangement with null-point measuring circuit. Provision was made for making an absolute measurement of the intensity of the ultraviolet radiation from a five-watt germicidal lamp which gives 95 percent of its radiation at 2537A. Operating from 110-volt a-c, a portable alternator was used in the field as a power supply. The instrument can be operated on d-c by making a few simple modifications.

The principle of operation of the instrument, whose electrical circuit is illustrated in Fig. 1, is to balance by means of camera diaphragms the light being received by the two phototubes $P_1$ and $P_2$ until the emf drop across the resistance $R_1$ is zero, and then allow the air containing the toxic gas to flow through an absorption cell. Absorption of some of the ultraviolet light by the toxic gas upsets the balance producing an emf drop across $R_1$ which could be measured. Calibration of the instrument with known gas concentrations provided an accurate quantitative foundation for the work.

**FIG. 2—Professor Klotz (left) and Professor Dole of Northwestern demonstrate the ultraviolet photometer developed by them for gas analysis**

A completely assembled instrument with a General Electric photoelectric recording microammeter is shown in Fig. 2.

### *Applications*

Figure 3 illustrates a record of the concentration of chloropicrin gas in parts per million as a function of time in an experiment study-

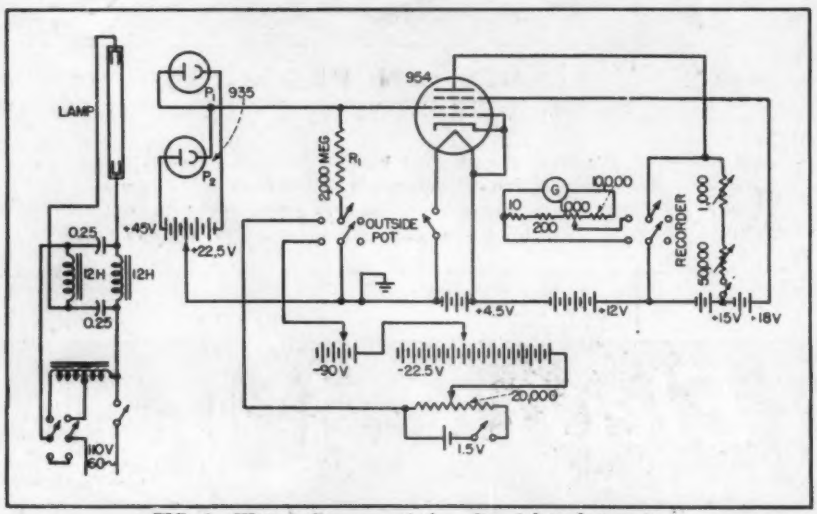



**FIG. 1—Wiring diagram of the ultraviolet photometer**

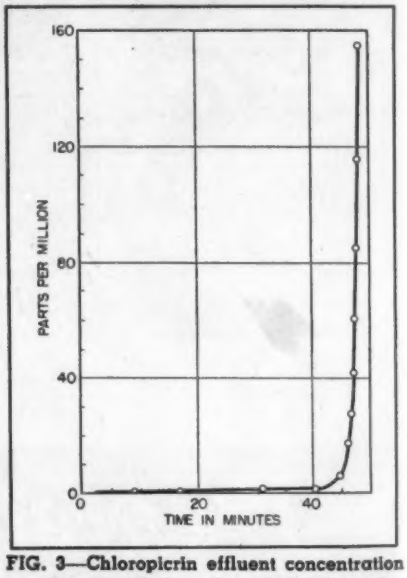
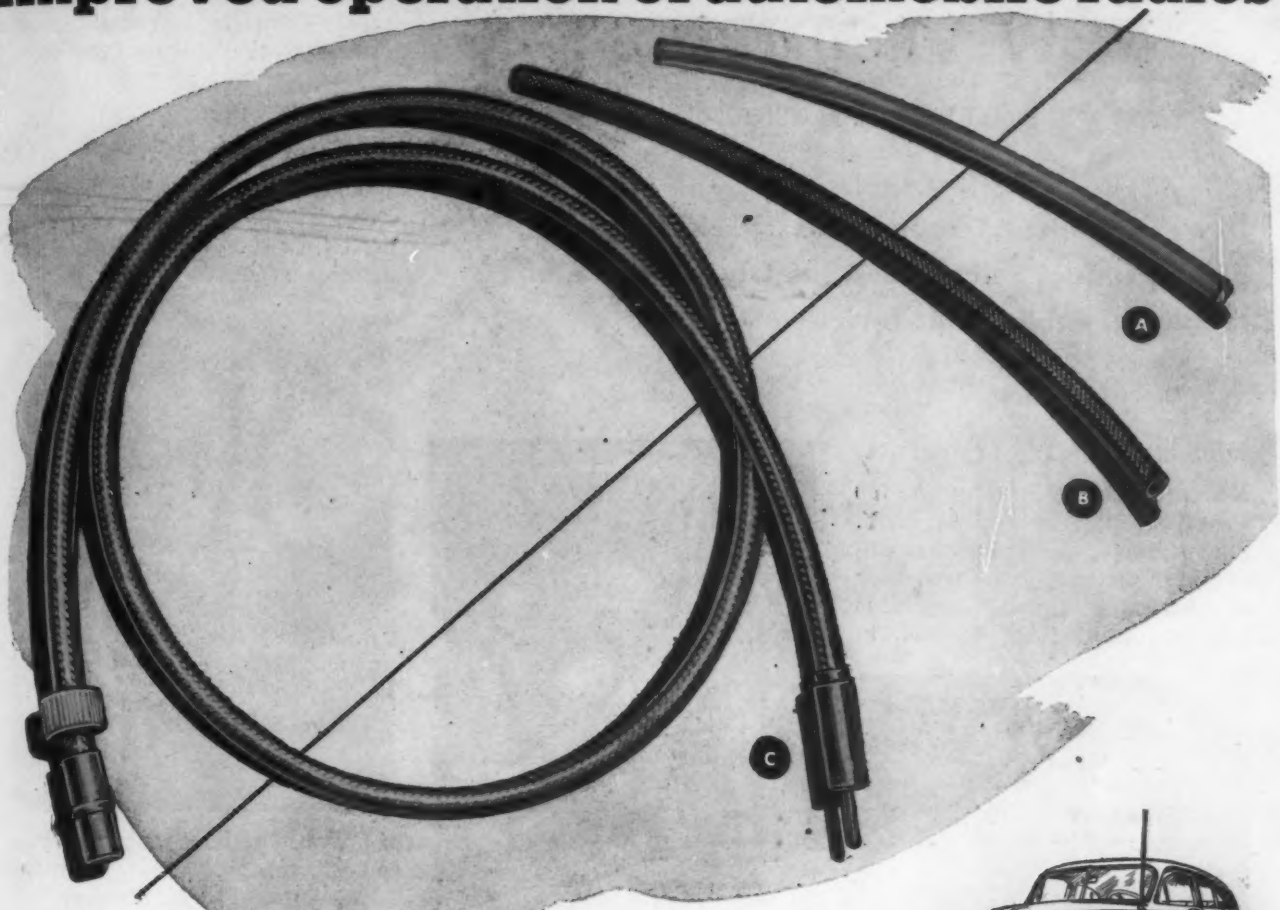


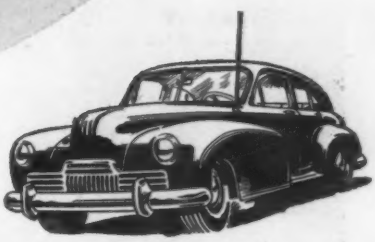

**FIG. 3—Chloropicrin effluent concentration as determined by the ultraviolet photometer**


(Continued on p 174)

# Improved operation of automobile radios




## with radio antenna lead-in cable insulated with Du Pont POLYTHENE



Now, with the use of Du Pont polythene, it is possible to make a lead-in cable, from the antenna to the instrument, that helps to assure proper operation of automobile radios—a lead-in cable that is water-tight, has excellent electrical properties, is economical to assemble, and gives long service.

Du Pont polythene has been successfully used as the insulating material for the shielded lead-in tubing made by The American Brass Company, Waterbury, Conn., because it has low capacitance and is usable over a wide range of temperatures. In addition, Du Pont polythene has these other outstanding advantages:

**RESISTANCE TO MOISTURE—Polythene has low moisture permeability, protects the cable from short circuits caused by moisture.**

**LASTING FLEXIBILITY—Polythene withstands twisting and bending over a wide range of temperatures.**

**HIGH "Q"—Electrical losses within a polythene-insulated cable are negligible.**

**EASE OF HANDLING—Polythene has good extrusion qualities, is economical to assemble.**

Your insulating problem may be solved by using Du Pont polythene. Write us for complete information on this light-weight, durable insulating material. E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept. 152, Arlington, N. J.

*A Extruded tube of Du Pont polythene, Type PM-1, 0.125" I. D. x 0.200" O. D. (one of many sizes), used for inner core of shielded lead-in tubing for a radio antenna. Polythene is ideal for this core because it is easily extruded, is stabilized, retains electrical properties.*

*B Tinned copper basket-weave braid is woven over inner core of polythene to incorporate electrical properties necessary in shielded lead-in tubing.*

*C The outer jacket, Type PM-2 polythene, about 35 mils thick, adds neat appearance, seals out water.*

**Du Pont manufactures polythene molding powder. Commercial extruders convert polythene into the forms of**

DU PONT
REG. U.S. PAT. OFF.
Plastics
BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

# THE ELECTRON ART

Edited by FRANK ROCKETT


Cathode-ray Tube for Displaying Speech Waves.....142
Superconductive Radio-Frequency Detector.....142
Classroom Demonstration of Cathode Follower.....188
Calibrating Laboratory Standards Against WWV.....190
Impedance Measurements .....194
Radio Reflection from the Moon.....196
Microwave Spectroscope .....198
Modulation of Concentrated-Arc Lamp.....202
Electronics in the Food Industry.....206
Edison Effect .....208
Variable Electronic Capacitor.....210


## Cathode-Ray Tube for Displaying Speech Waves

DISPLAYING patterns of speech waves on a cathode-ray tube enables the deaf to communicate verbally. The technique is being studied at Michigan State Normal College as a teaching method whereby deaf children can learn to read speech patterns just as they would a printed text. Using the technique, the deaf can enjoy the radio and carry on telephone conversations.

The speech translator tube (*Jour Appl Phys*, p 891 November 1946) consists of a cylindrical tube in which the phosphorescent material is deposited on a peripheral band. The electron gun at the bottom of the tube projects an intensity-modulated beam at the axis of the tube. An external coil on the neck deflects the beam slightly. The electron beam then passes into an expanded section of the tube. A strong magnetic field perpendicular to the tube's axis deflects the electron beam radially so that it strikes the phosphorescent band. There is an accelerating anode at the top of the tube. The tube slowly rotates to provide the sweep so that, to a stationary observer, the pattern appears to move from right to left. One reads against the motion of the pattern; that is, one reads from left to right. Both intensity modulation of the beam and deflection produced by currents in the coil on the neck provide means for representing the speech wave on the screen. Used in this way the rotating tube constitutes a sound spectrograph displaying the signal as a continuously moving pattern. Electrical connections to the tube are made through slip-rings.

The modified cathode-ray tube has a long-persistence phosphor on a cylindrical screen. When mounted in a strong perpendicular magnetic field and slowly rotated, the tube displays a continuous pattern of the speech wave

Professor Harriet Green speaks into the microphone. Patterns of the speech waves move across the screen of the special revolving cathode-ray tube, the screen of which is at the left inside the light shield. Joyce Arnold and Richard Hudson read the patterns

For displaying visible sound (*Jour Aco Soc Am* p 1-88 July 1946), the speech wave can be modified to incorporate the selective and nonlinear effects introduced by an ear. It is anticipated that by this method the deaf will not only be enabled to hear with their eyes, although of course the sensations they receive will not be that of audibly hearing, but also learn to talk and to interpret the significance of sounds not directly associated with speech such as music and noises.

## Superconductive Radio-Frequency Detector

DEVELOPMENT of bolometers has progressed to the point where response times as fast as $5 \times 10^{-4}$ second are obtained (*Jour Opt Soc Am*, p 518 September 1946). Such bolometers respond to infrared waves intensity-modulated at voice

(continued on p. 186)

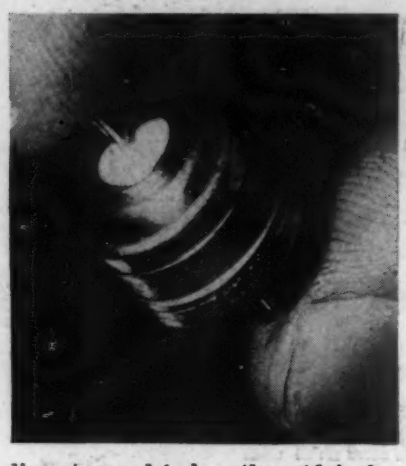
# NEW PRODUCTS

Edited by A. A. McKENZIE

**New equipment, components, packaged units, allied products; new tubes. Catalogs and manufacturers' publications reviewed**

### Dielectric Heater Crystal (1)

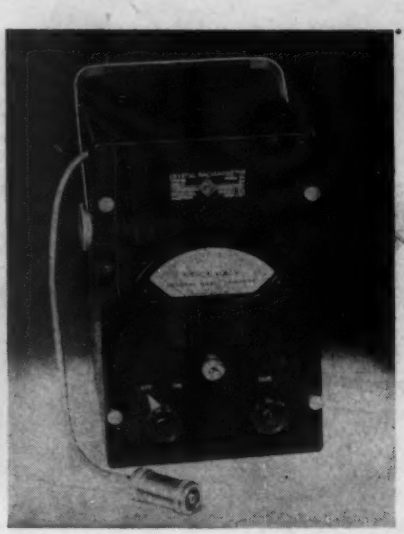
NORTH AMERICAN PHILIPS CO., 100 East 42nd St., New York 17, N. Y. A new midget quartz crystal oscillator for controlling the frequency of dielectric heating apparatus measures less than ⅜ inch in



diameter and is less than 1¼ inches long. Frequency coincides with that assigned by the FCC for this service and the unit is completely enclosed with soldering terminals provided for quick connection to the circuit.

### UHF Peak Voltmeter (2)

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. The type 1802-A crystal galvanometer directly measures 0.1 to 1 volt with an accuracy of ±5 percent at frequencies up to 1,000 megacycles. Two multipliers are furnished to extend the range to 10 or 100 volts. For the measurement of voltage ratios, the frequency limit can be pushed well above 1,000 megacycles. Functionally, the instrument is a peak-reading device employing a crystal rectifier, d-c



amplifier, and meter. Batteries required for operation are self contained.

### Television Lead-In (3)

ANACONDA WIRE AND CABLE CO., 25 Broadway, New York, N. Y. Two types of ATV two-wire polyethylene insulated line are available for television and f-m lead-in use, with characteristic impedances to match various types of antenna arrays. Complete information and prices are available on request.

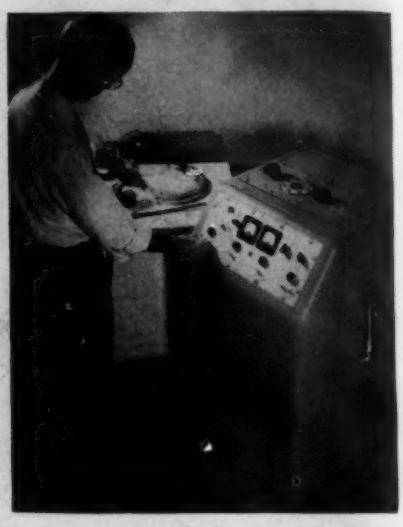
**USING THE NUMBERS**

Readers desiring further details concerning any item listed in the *New Products* department can obtain the information by using the cards furnished as a stiff, colored insert elsewhere in this department.

Place the number (appearing to the right of the heading) of one item in which you are interested in a circle and then fill out the balance of the card according to directions appearing on the colored sheet.

### Vacuum Leak Detector (4)

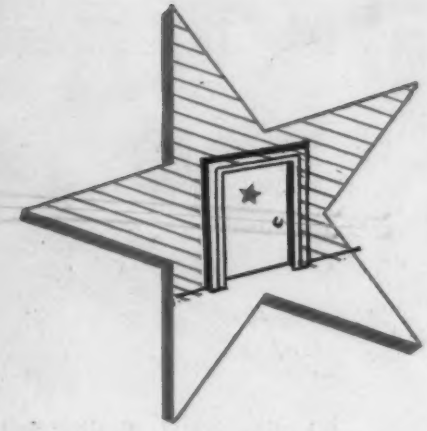
CONSOLIDATED ENGINEERING CORP., Dept. BB, 620 N. Lake Ave., Pasadena 4, Calif. A new portable leak detector model 24-101 for vacuum



or pressure systems that will locate and measure leaks as minute as 0.00000001 cubic centimeters per second works on the mass spectrometer principle. The instrument operates electronically to detect small quantities of helium introduced into suspected areas. The warning system contains an audio signal that changes pitch to indicate magnitude of the leak. The cabinet housing the equipment measures 43x25x22 inches and is mounted on ball bearing casters.

### Flaw Detector (5)

GENERAL ELECTRIC CO., Schenectady, N. Y. A new flaw detector that continuously detects weak spots and conducting paths in thin materials such as paper, sheet rubber, plastic material, and enamel films has recently been announced. The apparatus can be used with materials up to 0.025 inch thick moving as fast as 450 feet per minute and wire moving up to 100 feet a minute. Principle of operation depends upon applying an adjustable voltage to the material undergoing test and detecting the flow of current through the material when a flaw



# It's PERFORMANCE that COUNTS

***On the assembly line or in the laboratory Visual Alignment Techniques insure better performance.***

**HIGH FREQUENCY VISALGEN**
***Model 205 TS***

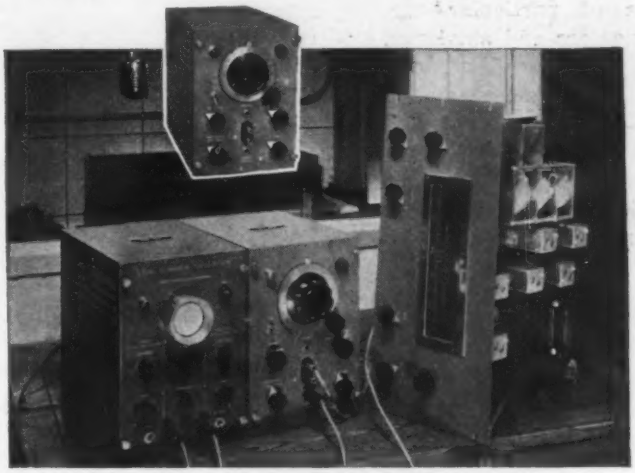
1. Frequency range from 100 kc to 20 mc.
2. Linear frequency sweep deviation adjustable from 0 to 900 kc peak to peak.
3. Vernier frequency control of 100 kc allows zero beat calibration of main tuning dial or for vernier frequency deviation about main dial frequency setting.
4. Output impedance 1 ohm to 2,500 ohms.
5. Voltage regulated supply for internal oscillators.

**LOW FREQUENCY VISALGEN**
***Model 204 TS***

1. Frequency range from 20 kc to 500 kc.
2. Linear frequency sweep deviation adjustable from 0 to 70 kc peak to peak.
3. Low pass filter in the output to minimize spurious output frequencies.
4. Output impedance constant 200 ohms.
5. Output attenuation: 5-step ladder type — 20 db per step.

**OSCILLOSCOPE**
***Model 188 TS***

1. New simplified circuit for use with either model Visalgen.
2. Simplified for visual alignment work.
3. Compact design — light weight.
4. Immediately available, also available with either model Visalgen complete in one cabinet.

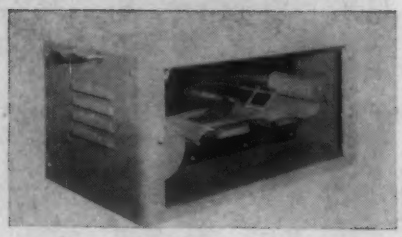


**Visalgen Model 205 TS being used with 188 TS oscilloscope to align Harvey Hi-Fidelity FM Receiver.**

***Inset:* New Low Frequency Visalgen Model 204 TS**

HARVEY OF CAMBRIDGE

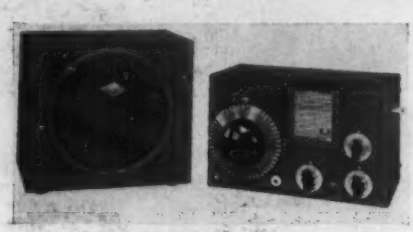
**HARVEY RADIO LABORATORIES, INC.**
**439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS**



passes. The equipment can be set up close to the manufacturing process in order to spot variations in quality immediately.

## VHF Receiver (6)

NATIONAL CO., Malden, Mass. The NC-One-Ten-A radio receiver has been redesigned as a result of radiosonde use and represents an improvement over the original receiver that tuned the spectrum



from one to ten meters. Although the instrument has many practical applications, such as reception in the 118-megacycle aircraft band, it is of particular use to experimenters and amateurs.

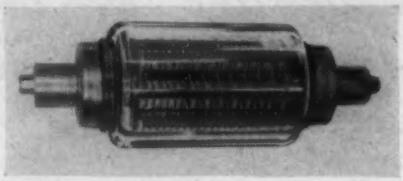
## High Mu Triode (7)

NATIONAL UNION RADIO CORP., 57 State St., Newark 2, N. J. An amplification factor of 500 at plate voltage ratings from 1 to 8 kilovolts is possible with the type 2C53 tube. At plate voltages between 250 and 400 volts, it is possible to obtain single stage amplification from 250 to 300 times. The tube has been particularly designed for

regulation of low-current power supply voltages up to 8 kilovolts, such as in pulse amplifiers, for high-impedance measurements, and in television equipment.

## Vacuum Capacitor (8)

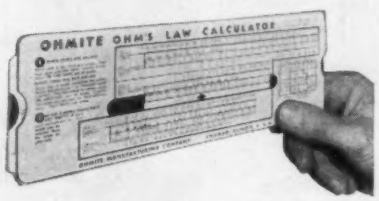
RAYTHEON MFG. CO., Waltham, Mass. The type RC100-20 vacuum capacitor is the first in a new line of high-voltage, high-current components designed for tank circuits in industrial and communications oscillators. The new unit, which has a capacitance of 100 micromicrofarads, can be used at r-f volt-



ages up to 20,000 and will carry an rms current of 60 amperes. Overall length of the capacitor is 7.25 inches and diameter is 2.5 inches.

## Ohm's Law Calculator (9)

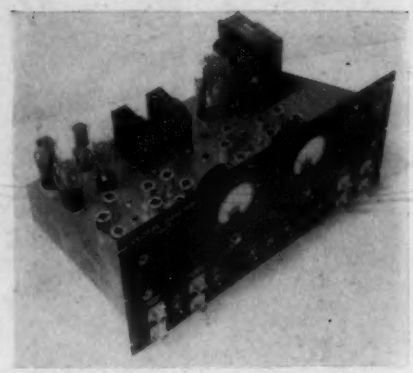
OHMITE MFG. CO., 4937 Flournoy St., Chicago, Ill. A new pocket-size calculator reads directly in ohms, volts, amperes and watts. It will also solve parallel resistance and series capacitance problems, will




multiply, divide and find squares or square roots. Composition resistor color coding is also shown. The calculator measures 3x9 inches and sells for 25¢.

## Decade Counter (10)

GENERAL ELECTRIC CO., Syracuse, N. Y. A new decade scaling unit for use with particle detectors will respond to impulses of 0.05 microsecond duration separated by only



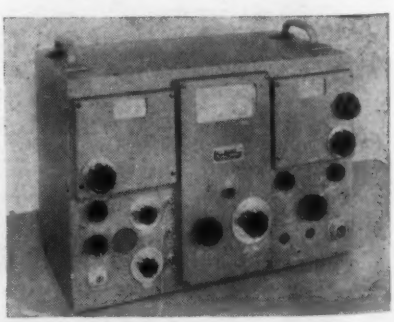
0.1 microsecond. Scaling factor of the type YYZ-1 unit is either 10 or 100, but units can be used in cascade to provide factors of 1,000 or more. Impulse duration and resolution times were incorrectly reported in a previous announcement of this product.

## Television Receiving Antenna (11)

WORKSHOP ASSOCIATES, INC., 66 Needham St., Newton Highlands 61, Mass. Primarily designed for single-channel operation in locations where signal-to-noise ratio is low, the new series of television receiving antennas aims to improve reception only in poor locations. There are separate structures available for each of five bands. Price exclusive of standard coaxial cables is $28.50 each.

## Field Intensity Meter (12)

CLARKE INSTRUMENT CORP., 910 King St., Silver Spring, Md. The model 106 field intensity meter for use in the television and f-m bands covers the frequency range 50 to 220 mc. The instrument is direct reading in terms of microvolts per meter over a range of 5 microvolts to 10 volts. Selectivity is adequate for measurements on adjacent f-m

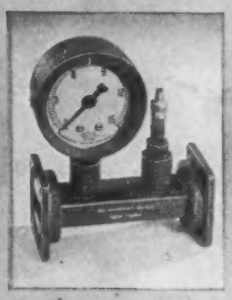


# EVERY DE MORNAY-BUDD WAVE GUIDE
## is Electrically Tested, Calibrated and Tagged

Crystal Mount DB-453

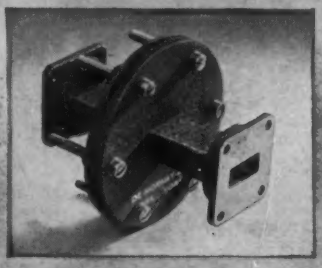
Rotating Joint DB-446

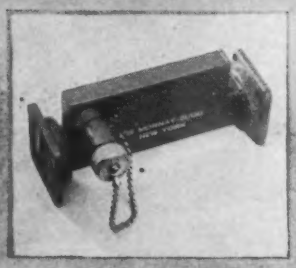
90° Elbow (H Plane) DB-433


Pressurizing Unit DB-452

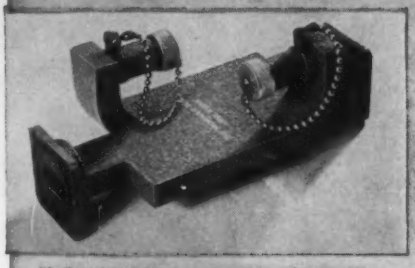
Mitered Elbow (H Plane) DB-439

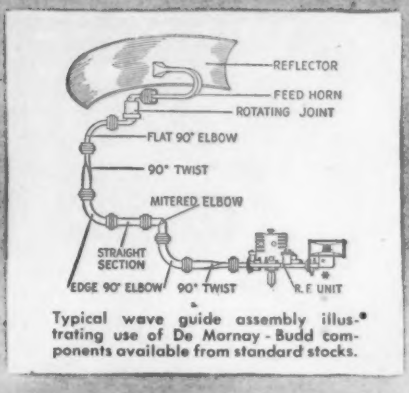
Uni-directional Broad Band Coupler DB-442


Bulkhead Flange DB-451

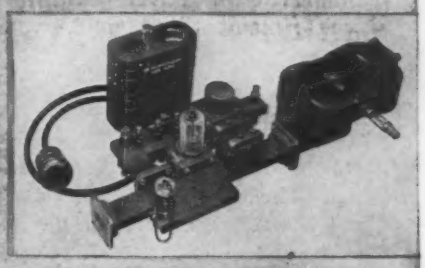

Uni-directional Narrow Band Coupler DB-440

90° Twist DB-435


Bi-directional Narrow Band Coupler DB-441



Typical wave guide assembly illustrating use of De Mornay - Budd components available from standard stocks.


RF Radar Assembly DB-412

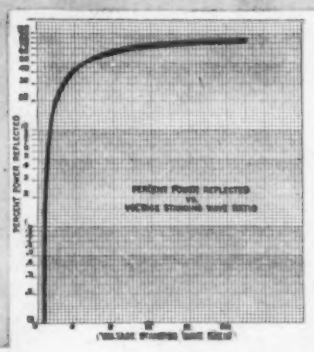
When you use any De Mornay·Budd wave guide assembly, you know exactly how each component will function electrically. You avoid possible losses in operating efficiency through impedance mismatches, or breakdown and arcing caused by a high standing wave ratio. (See chart below.)

De Mornay·Budd wave guides are manufactured from special precision tubing, and to the most stringent mechanical specifications. Rigid inspection and quality control insure optimum performance

**NOTE: Write for complete catalog of De Mornay·Budd Standard Components and Standard Bench Test Equipment. Be sure to have a copy in your reference files. Write for it today.**

**The curve shows the manner in which the reflected power increases with an increase in the voltage standing wave ratio. The curve is calculated from the following equation:**

$$\% \text{ Power Reflected} = \left( \frac{\left(\frac{V_{max}}{V_{min}}\right) - 1}{\left(\frac{V_{max}}{V_{min}}\right) + 1} \right)^2$$



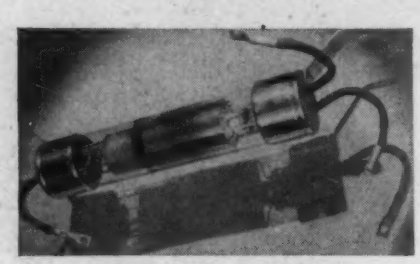

DE MORNAY BUDD
EQUIPMENT FOR 97% OF ALL RADAR SETS

De Mornay-Budd, Inc., 475 Grand Concourse, New York 51, N. Y.

channels 200 kc apart. A 110-volt power supply can be substituted for the vibrator supply incorporated in the equipment.

## Rectifier Tube (13)

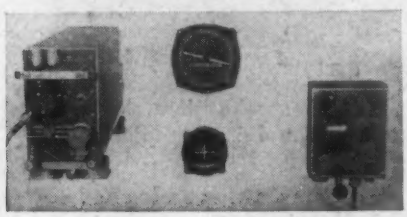
ELECTRONS INCORPORATED, 127 Sussex Ave., Newark 4, N. J. A new half-wave xenon gas-filled rectifier type 16F has been designed for applications in rectifier circuits giving up to 96 amperes d-c at voltages varying from 24 to 600. Characteristics include: average anode cur-



rent, 16 amperes; peak anode current, 96 amperes; peak inverse voltage, 620 volts; average arc drop, 7 volts; filament voltage, 2.5 volts.

## Navigation Receiver (14)

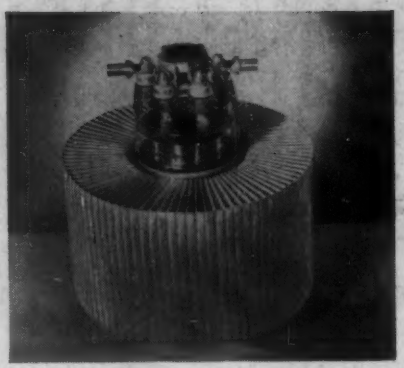
RADIO CORP. OF AMERICA, Camden, N. J. The new type AVR-25 aircraft communications and navigation receiver consists of four units —control box, azimuth indicator,



left-right indicator, and receiver proper. The latter unit operates on all the aircraft vhf channels and makes possible the use of two-course visual ranges as well as the omnidirectional range.

## F-M Broadcast Tube (15)

WESTERN ELECTRIC CO., 195 Broadway, New York 7, N. Y. The type 5541 air-cooled transmitting triode has been designed particularly for use in the company's 10-kw f-m transmitter, but can be adapted for



use in grounded-plate, grounded-grid, or grounded-cathode circuits. Design features include a thoriated tungsten filament, low-inductance and high-conductivity leads.

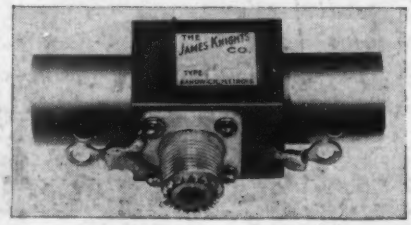
## V-T Test Set (16)

SYLVANIA ELECTRIC PRODUCTS, Inc., 500 Fifth Ave., New York 18, N. Y. The console unit illustrated includes bridge and auxiliary switch gear mounted on the control shelf,

electronically regulated power channels, bridge signal source, amplifier, meters, and other accessories conveniently located for tube tests and maintenance. The console is 55 inches high, 70 inches long, and 34 inches deep. It weighs 1,500 pounds.

## Current Feed Junction (17)

JAMES KNIGHTS CO., Sandwich, Ill. The Impedacoupler is essentially an




insulating block with ends machined to take standard aluminum or dural tubing having 1-inch outside diameter. It is fitted with an Amphenol type 1R receptacle that takes a type 1SP cable connector. The unit has several uses, such as center feed point of a half-wave doublet.

## Rugged Speaker Driver (18)

UNIVERSITY LOUDSPEAKERS, INC., 225 Varick St., New York 14, N. Y. A new loudspeaker driver unit capable of handling up to 12 watts of audio power features an Alnico V magnet and one-piece phenolic diaphragm. The voice coil is wound on a duralumin band for maximum heat dissipation. Impedance of the unit is 8 ohms and its frequency

range covers 100 to 6,000 cycles. It is 3 inches high with a diameter of 3½ inches.

## Zinc Solder (19)

SUPERIOR FLUX CO., 901 Public Square Bldg., Dept. 1, Cleveland, Ohio. Zinctite is a self-reacting fluxless solder that can be used for soldering copper, brass, steel or zinc pieces to zinc or zinc-base alloys. It comes in the form of a paste in ½, 1, or 5 pound jars.

## Crystal Microphone (20)

BRUSH DEVELOPMENT CO., 3405 Perkins Ave., Cleveland 14, Ohio. The model BA-106 microphone is manu-

(Continued on p. 212)

# SMALL PARTS
## DIAMOND G MAKES THEM!

Whatever your need in small parts—lock washers, flat washers, special washers, snap and retainer rings, stampings of all kinds and hose clamps, Diamond G is ready to make quick deliveries. Diamond G also offers its complete facilities to produce special parts you may need in your products. Diamond G Engineers stand ready to help you in every way.

Another Diamond G service to industry is the new lock washer specification and data book . . . "How, Why and Where of Lock Washers." A booklet every purchasing agent, design engineer and production man should have. Yours without obligation. Just write to . . .

**GEORGE K. GARRETT COMPANY, INC.**
1421 CHESTNUT ST., PHILADELPHIA, 2

### FINISHING WASHERS

Diamond G makes a full line of hollow and flush type finishing washers. Available in all finishes and types of metals.

### SPECIAL WASHERS AND STAMPINGS

A complete range of sizes are available in Diamond G special "C" washers. Unusual stampings of all kinds produced in Garrett's modern stamping plant which turns out millions of stampings.

### SPRING STAMPINGS

Garrett's modern facilities for stamping and precision heat treating make it possible to produce spring stampings of the highest quality. Producing special spring stampings to exact specifications in an amazingly short period of time is a specialty of Garrett's.

### SPRING WASHERS

Diamond G has built an outstanding reputation for producing a wide variety of spring washers. They offer manufacturers an excellent source of supply for special shaped, curved, dished and cupped spring washers.

### FLAT WASHERS

Outstanding in the Diamond G line of products are the many flat washers made by Garrett's. It offers industry a quick and dependable source of a complete line of flat washers including SAE, machine-screw, and aircraft washers in all sizes, thickness, metals and finishes. Garrett's also produce a complete line of snap, space and retainer rings for all types of industrial installations.

### HOSE CLAMPS

Garrett's line of hose clamps includes both types to provide the manufacturer with the answer to his problems. The Diamond G Multi-Clamp is the ideal clamp of a thousand uses which can be used on automotive, hydraulic, pneumatic, electronic and aviation installations. The Diamond G Auto-Seal Clamp is truly the all-purpose economy clamp for every industrial use . . . is rugged and provides a tight seal on every joint.

# DIAMOND G PRODUCTS

LOCK WASHERS • • FLAT WASHERS • • STAMPINGS • • SPRINGS • • HOSE CLAMPS • • SNAP AND RETAINER RINGS

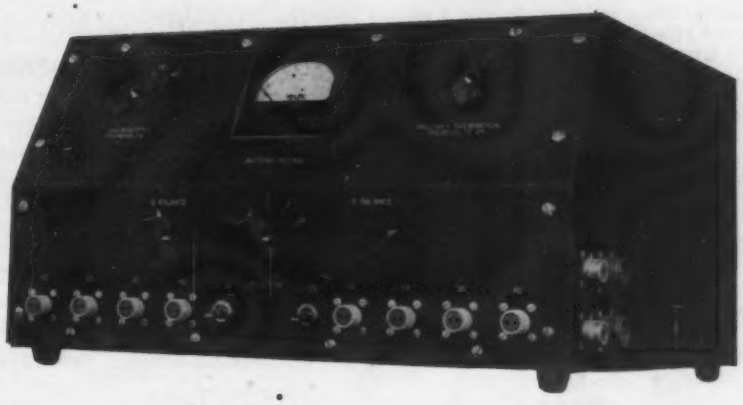
# VERSATILITY *in the*

## *Design - Development - Production of* LF, HF *and* UHF *Equipment*

*For Example...*

**THE ELECTROMYOGRAPH**

**A Lavoie test instrument designed for the Medical profession. Amplifies minute potentials of the order of microvolts generated by muscles—to the extent that these potentials may be measured and analyzed. Includes calibration circuits to facilitate the taking of accurate data.**



**LAVOIE LABORATORIES** are well prepared with trained personnel and special equipment to handle every phase of design, develpment and manufacture of LF, HF and UHF equipment. As SPECIALISTS, you are assured of precision work based on correct methods and technique developed through years of practical experience.

**FREQUENCY STANDARDS • FREQUENCY METERS • RECEIVERS**
**TRANSMITTERS • ANTENNAS and MOUNTS**

*Detailed information and estimates of LAVOIE service are available promptly without cost or obligation.*

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

*Specialists* in the Development and Manufacture of LF and HF Equipment

# NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

**Worldwide status of television; production figures; new synchro-cyclotron; three-tube receivers for India; important meetings**

## Television Equipment Maintenance Course

A COURSE in Operation and Maintenance of Television Equipment is being offered for the first time by New York University, with classes being held Friday evenings at the DuMont television studios under the supervision of S. R. Patremio, chief engineer of DuMont's television station WABD. Fee is $50 for 15 sessions.

Prerequisite is satisfactory completion of two other NYU evening courses, in Television Circuits (Friday evenings for 15 weeks starting Feb. 7) and Ultrahigh-Frequency Television Circuits (Wednesday evenings for 15 weeks starting Feb. 5). There are no academic requirements, however, for these noncredit courses. Other evening courses offered in the Spring term cover Elements of Radio and Electronics (Friday evenings), and Applied Electronics (Thursday evenings). Further information can be obtained from S. G. Roth, New York University, Washington Square, New York 3.

## French Television Plans

AN EFFORT will be made to set a new higher-line standard for French television by early 1947, according to Andre Ory, director of Television Francaise, the governmental telecasting organization. Present broadcasts from the Eiffel Tower station use 450 lines.

The Societe Radio-Industrie has now developed an experimental set using 819 lines, with a new small iconoscope. M. Barthelemy, at the Compagnie des Compteurs, is working on a 1,015 line set; Thomson-Houston is perfecting its 500-900 line apparatus. Four-power interlacing has been tried by Television Francaise, but has not worked out.

## Cab and Truck Frequencies

THOUGH REQUESTS by representatives of taxicab and trucking groups for five-year experimental radiotelephone licenses have been denied by the FCC, qualified applicants will continue to be granted Class 2 experimental licenses for taxicab operation on 152.27 and 157.53 mc and for truck radio operation on 152.15 and 157.41 mc. Further applications for truck radio systems are invited, to speed the establishment of a permanent service.

## FMA is Launched

REPRESENTATION of commercial f-m broadcasters has been taken over by the newly organized Frequency Modulation Association, with Judge Roy Hofheinz of KTHT

(continued on p 250)

**IRE Winter Convention March 3-6, 1947—Technical Program**

| | HOTEL COMMODORE | | | GRAND CENTRAL PALACE | |
|---|---|---|---|---|---|
| Room | East Ballroom | Main Ballroom | West Ballroom | Auditorium I | Auditorium II |
| Seating Cap. | 500 | 2,000 | 400 | 450 | 450 |
| Monday 2–5 p.m. | | Particle Accelerators for Nuclear Studies | Electronic Measuring Equipment | Radar & Communication Systems | F-M Reception |
| Tuesday 10–12:30 p.m. | Aids to Navigation | | Nucleonics Instrumentation | Microwave Components and Test Equipment | Television A |
| Tuesday 2:30–5 p.m. | Television B | | Electronic Digital Computers | Power Output Vacuum Tubes | Circuit Theory |
| Wednesday 10–12:30 p.m. | Electronic Controls & Applications | Aids to Air Navigation & Traffic Control | | Microwave Techniques and Measurements | Broadcasting & Recording |
| Wednesday 2:30–5 p.m. | | On The Professional Status of the Engineer | | | |
| Thursday 10–12:30 p.m. | Oscillator Circuit Theory | | Basic Electronics Research | Wave Propagation and Antennas | Relay and Pulse-Time Systems of Communication |
| Thursday 2:30–5 p.m. | Receiver Circuits | | Vacuum Tubes and Gas Rectifiers | Antennas | Wave Guide Techniques |

**A total of 120 highly technical papers covering most recent developments in radio and electronic engineering will be presented this year by the Institute of Radio Engineers at its annual convention March 3rd to 6th inclusive, in accordance with the above schedule. The accompanying show is at Grand Central Palace this year for the first time, with over 150 manufacturers slated to show their products**

# IS READY TO SERVE THE NATION

FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON 25, D. C.

ADDRESS ALL
TO THE

November 27, 1946

Mr. John Curtis, Manager
Mobile Communications Division
Farnsworth Television & Radio Corp.
Fort Wayne 1, Indiana

Dear Mr. Curtis:

I wish to thank you for your letter outlining the excellent progress which the Farnsworth Television and Radio Corporation has made in developing and producing various types of equipment for railroad radio communication. I was especially pleased to read that section of your report which quotes various railroad presidents who recognize that radio will enhance safety and efficiency in railway operations.

As you know, the Commission has been convinced for some time that a properly engineered railroad radio system will contribute to safety of life and property, both in preventing accidents and in reducing the seriousness of injury and damage after accidents. While safety is of paramount importance we also recognize and encourage the use of radio as a means of improving the overall efficiency of the railroads.

Sincerely yours,

E. K. Jett,
Commissioner

Commissioner Ewell K. Jett has been a motivating factor in the development of radio communications since the pioneering days of the early 20th Century. From 1911-1929 he participated in the development of the Navy's use of what was then a new communications art. Since 1929, Mr. Jett has been associated with the Federal Communications Commission and its predecessor, the Federal Radio Commission, first as Assistant Chief Engineer; then, since February 1, 1938, as Chief Engineer. On February 15, 1944, Mr. Jett was appointed Commissioner.

Throughout his career with the Navy and the Commission, Mr. Jett has been alert to the ever-increasing usefulness of radio in mobile operations. More recently, with the development of radio equipment for railway and highway services and Mr. Jett's origination of the Citizens' Radio Communication Service, his activities wth the Commission have taken on even more significance to American economy and well-being.

*Farnsworth*

*Television · Radio · Phonograph-Radio*

Farnsworth Radio and Television Receivers and Transmitters · Aircraft Radio Equipment · Farnsworth Television Tubes · Mobile Communications and Traffic Control Systems for Rail and Highway · The Farnsworth Phonograph-Radio · The Capehart · The Panamuse by Capehart

# Farnsworth RAILROAD RADIO

### A MILESTONE IN RAILROAD RADIO!

"Modern railroad transportation systems cannot function to their maximum efficiencies without the use of modern communications networks. That is why the Santa Fe System maintains complete telephone and teletype, as well as telegraph systems along its entire thirteen-thousand-mile right-of-way. It is also the reason for Santa Fe's immediate and careful exploration of all new communications techniques, such as railroad radio, and accounts for the many 'firsts' contributed by the Santa Fe to the railroad communications art."

President
Atchison, Topeka and Santa Fe Railway

### "RAILROADS . . . LIKE A GIANT CONVEYOR BELT"

"The war has emphasized the importance of American railroads. Like a giant conveyor belt, they link up the industrial, agricultural and mining areas of this country with the many thousands of markets that dot our land. With reconversion a fact, far-sighted railroad management is carefully exploring many technical war developments, and, in particular, radio, with the expectation that radio will help keep American railroads the safe, efficient and modern network of transportation which has so ably served the Nation during the war."

### "THIS PIONEERING EFFORT . . ."

"The Chicago and North Western Railroad, always interested in technological developments which promise improvement in the efficiency and safety of railway operations, participated in the first regular use of very high frequency railway radio. This installation went into operation in our Proviso Yards in September, 1940, and continued for over a year thereafter.

"We are happy that the technical and operating information secured from the pioneering effort was subsequently useful to the Army Ordnance Department and to the operators of the large Army Ordnance Plants in making their decision to use railroad radio in connection with the war effort.

"The case histories provided by the use of radio at Proviso and in the large ordnance plants were later to become an important part of the railroad testimony in the Federal Communications Commission hearing which brought about the present allocation of frequencies for railway use."

PRESIDENT,
Chicago and North Western Railway System

Farnsworth radiotelephone systems, now ready to serve the Nation's railroads, provide:

### (1) RELIABLE RADIOTELEPHONE CIRCUITS

Farnsworth guarantees its railroad radiotelephone systems for a period of one year—the same kind of comprehensive guarantee furnished with U. S. Government war-time radio equipment on which battles and lives depended.

### (2) IMPROVED OPERATING SERVICES AND FACILITIES

Radiotelephone circuits between train crews and supervisory personnel permit industrial customer requirements to be fulfilled more rapidly; provide reliable and instantaneous communications even during adverse visibility conditions; enable the quick reporting of equipment failures and the more rapid and efficient dispatching of relief; permit crews instantly to report unscheduled stops to near-approaching trains.

### (3) SAVINGS IN OPERATIONS

Railroads using modern radiotelephone circuits have reported through official Association of American Railroads documents convincing proof of the important money-saving, as well as safety-contributing abilities of radiotelephone circuits.

### (4) LOW-COST INVESTMENT AND MAINTENANCE

Farnsworth equipment incorporates such important operating and maintenance features as standardized chassis with unitized construction, low-clearance antennas, automatically engaging plug-in type connectors, and special test circuits. The combination of these features, *found only in Farnsworth equipment*, guarantees maximum availability, flexibility, and usefulness with simplified low-cost maintenance. Yet, Farnsworth railroad radio equipment is priced competitively with other quality systems, many of which lack these special features.

For detailed particulars of Farnsworth Mobile Communications Systems, write Farnsworth Television & Radio Corporation, Dept. E-2, Fort Wayne 1, Indiana.

### "TO ATTAIN STILL HIGHER STANDARDS OF SERVICE . . ."

"An asset in which the Nickel Plate Road takes great pride is the high standard of service which it renders to the shipping public. With its record for outstanding performance during the war years back of it, the Nickel Plate is looking forward to the utilization of new technological developments, such as radio and teletype, in order to attain still higher standards of service and usefulness."

President,
The New York, Chicago & St. Louis R. R. Co.

### "Train Radio to Aid in Operation of Pere Marquette's New Streamlined Trains"

"By virtue of their efficient and effective performance during the war, the nation's Railroads have won the respect and goodwill of the American people. It is essential that this public esteem be maintained. That is why progressive railroad managements are planning the use of many technical developments capable of making additional contributions to the safety and comfort of rail passenger service and why the new, streamlined passenger trains which Pere Marquette soon will put into operation are to be equipped with train radio communication systems."

President
Pere Marquette Railway Company

since 1935
the only VOLTMETER
featuring a simplified
LOGARITHMIC SCALE

10 MICROVOLTS
to 100 VOLTS
with the
BALLANTINE
ELECTRONIC VOLTMETER
and DECADE AMPLIFIER

**RECOMMENDED** .....
*By American Standards Association (Bulletin C75.17-1944)* as being exceptionally well-suited for establishing a uniform method of noise-testing fixed composition resistors. The high sensitivity, averaging type of indication, and stable operation make the above combination ideal for making noise measurements. Model 300 Voltmeter reads from .001 to 100 volts and Model 220 Decade Amplifier supplies standardized gains of 10x and 100x. Frequency range 10 cycles to 150 kilocycles.

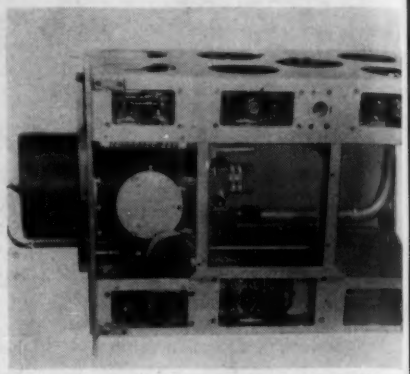
*Descriptive bulletin available*

**BALLANTINE LABORATORIES, INC.**
BOONTON, NEW JERSEY, U.S.A.

 (continued from p 138)

mitted and received 54 channels of data.

In the plane, dial-type instruments, rows of small galvanometer light-beam indicators, and breakage indicator lights formed the television theater. The dial instruments included an airspeed indicator, altimeter, normal accelerometer, longitudinal accelerometer, rate of pitch indicator, and angle of dive indicator. Forty-eight light beams indicated pressures, strains, positions of control surfaces, voltages, currents, and rates of roll, pitch and yaw. Fifteen breakage indicator lights warned of possible structural failures in flight.



**Top view of the conversion-modulator transmitter of the Farnsworth television telemetering system**

The strongly lighted panel was faced by a 23-tube television camera-transmitter. A complete image of the panel, showing all movements of its dial hands and light beams, was picked up by a Farnsworth image dissector tube for transmission to the ground station.

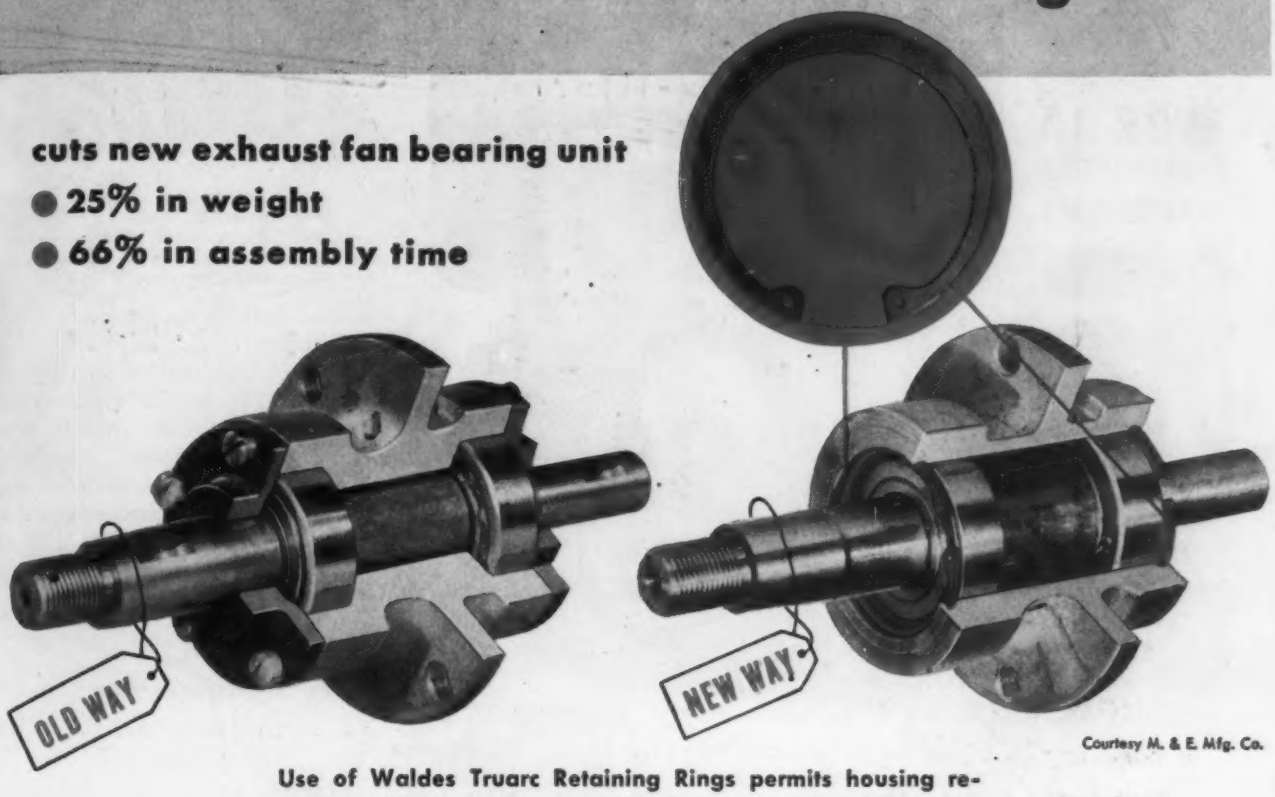
The television theater and camera-transmitter units were locked together in a sealed aluminum pressure-box, inside which a temperature control system operated to keep the temperature as constant as possible while the outside reading was varying between 75 and −67 F. The pressure-box was designed to operate at an altitude of 60,000 feet.

The transmitting antenna, a crossed-dipole type, had four half-wave radiators phased to give a spherical field and projected straight back from the tail of the fuselage. In this position it was relatively unaffected by shadows cast by the plane in a dive or spin. The average power of the transmitter was 25 watts, and the signal

# TRUARC trims 13 minutes machining to 6

**cuts new exhaust fan bearing unit**

- **25% in weight**
- **66% in assembly time**




Courtesy M. & E. Mfg. Co.

**Use of Waldes Truarc Retaining Rings permits housing redesign—eliminates heavy cast bearing caps and screws requiring drilling and tapping; lowers labor and material cost.**

"TRUARC PAYS DIVIDENDS IN SAVINGS!" declares M. & E. Manufacturing Company, of Indianapolis, makers of exhaust fans for industry. "Improvements in design made possible by Waldes Truarc Retaining Rings provide a quieter, freer-running assembly, assure longer life to the entire unit, eliminate the hazards of uneven unnecessary pressure on the bearing and minimize future service requirements. In our experience Truarc has definitely proved itself the better method for doing an important job."

Truarc does a better job on axles and shafts for retaining and positioning wheels, pulleys, cams and gears. In widely varied applications, designers find its never-failing grip, its patented design that assures constant circularity, make Truarc the better way to hold machine parts together. Production and maintenance men in many industries see how Truarc rings cut costs sharply, maintain accurate, unvarying relationship of parts. Send us your drawings; Waldes Truarc engineers will be glad to show how Truarc can help you.

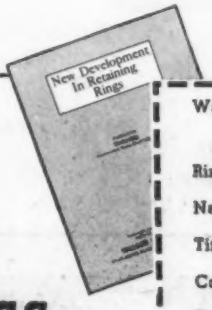
**WALDES**

# TRUARC

U. S. PATENT RE. 19,144

**RETAINING RINGS**

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK




● ***Send for new Truarc booklet, "New Development In Retaining Rings"***

Waldes Kohinoor, Inc., 47-10 Austel Place 18-K
Long Island City 1, N. Y.

Please send booklet, "New Development In Retaining Rings" to:

Name_____

Title_____

Company_____

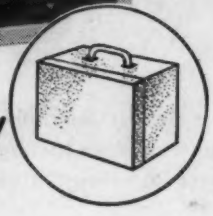
Business Address_____

City_____ Zone____ State_____

NEW
TECH-LAB DEVELOPMENT

For RAPID MEASUREMENT OF AUDIO FREQUENCY GAIN or LOSS

TYPE 1A
TRANSMISSION
MEASURING SET



Completely Self-Contained
PORTABLE • AC OPERATED

With this instrument it is possible to quickly and accurately analyze and service equipment in different locations without fuss in time consuming demounting and transportation of apparatus. It will thus pay for itself in a short time and no modern radio station can afford to be without it. It can also be used to good advantage in factory checking and inspection of audio equipment.

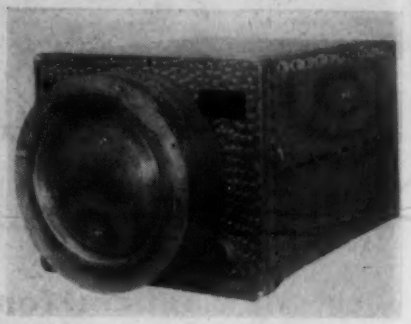
The set combines in a modern efficient manner an accurate vacuum tube voltmeter, an audio oscillator with four fixed frequencies and a precision attenuator all mounted in a handy cabinet easily carried by the operator.

SPECIFICATIONS

- GAIN: Up to 80 db.
- LOSS: 60 db. maximum.
- VACUUM TUBE VOLTMETER: Range—40 to +40 db. (1 mv. ref. level)
- AUDIO OSCILLATOR: Freq. Range; 100 to 10,000.
- PRECISION ATTENUATOR: Flat to 20 KC; 93 db. in .1 db. steps.
- DIMENSIONS: 10¼" x 16¼" x 8¾"
- WEIGHT: 30 lbs.
- INPUT: 115 Volts, 60 cycles, 70 watts.

TECH LABORATORIES, INC.
Manufacturers of Precision Electrical Resistance Instruments
337 CENTRAL AVE. • JERSEY CITY 7, N. J.





Pressure box containing the main chassis of the Farnsworth air-borne television transmitter. Excess heat from the chassis at low altitudes is passed to the radiating-fin assembly on one end

radiated had an approximate limit of 25 miles.

The receiving station was mounted on a 1½-ton truck. This vehicle contained a receiver which provided a 350-line picture, a recording unit to film all transmissions, and equipment for two-way voice radio communications with planes in flight. Folding antennas were mounted on the roof.

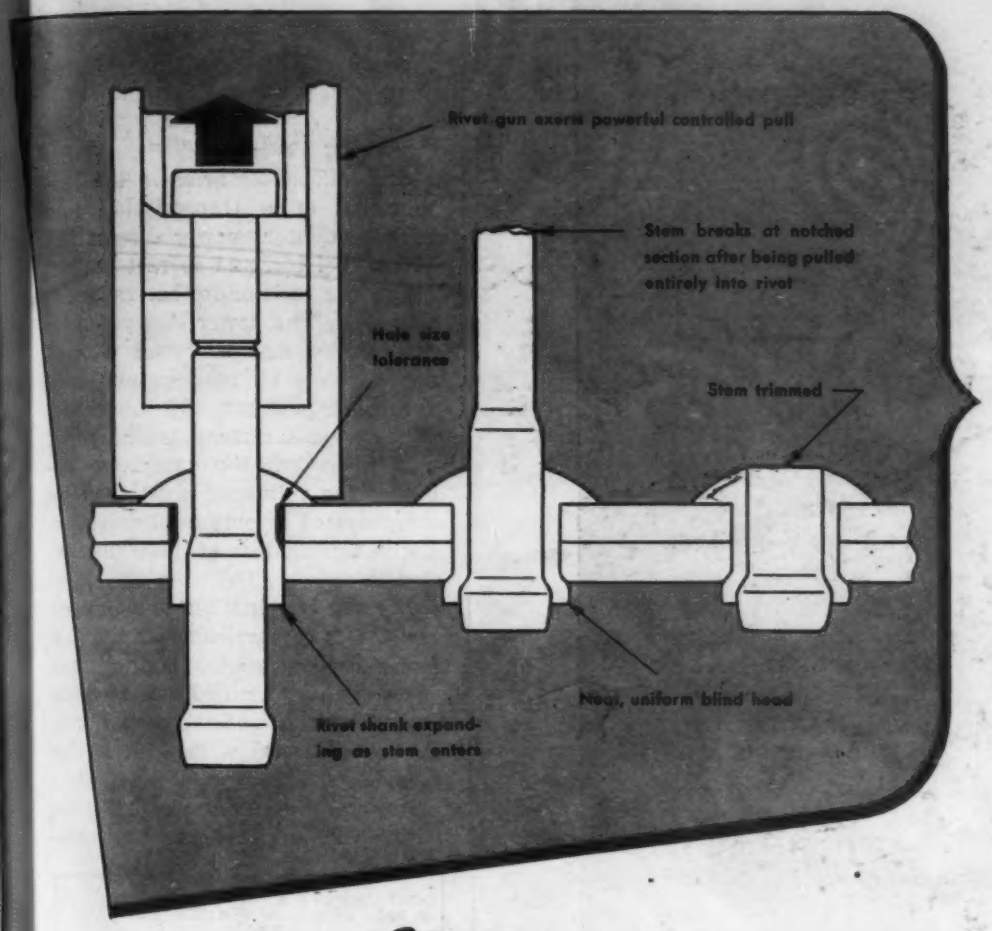
## VHF Transmitter Power Measurements

By LEONARD R. MALLING
*Seattle, Washington*

INCREASING USE of the vhf spectrum has resulted in the need for an accurate and convenient method of measuring r-f power at frequencies ranging from 100 to 500 mc and powers ranging up to 100 watts.

Line of sight limitations, low weight requirements, the use of directive antennas and the need of portability has lead to a figure of the order of 50 watts maximum continuous power output for transmitters designed for vhf use. Pulse power of the order of kilowatts may be conveniently measured if the pulse rate is made low for output power tests.

Except when extreme portability is required, vhf transmitters are designed to work into coaxial cables feeding dipole arrays, so that for maximum efficiency the antenna system should be purely resistive. If we terminate the transmission line in a purely resistive load the power output of the transmitter can be determined by a knowledge of the power dissipation in this resistor. Maximum convenience is obtained by having a power meas-


Rivet gun exerts powerful controlled pull
Stem breaks at notched section after being pulled entirely into rivet
Hole size tolerance
Stem trimmed
Neat, uniform blind head
Rivet shank expanding as stem enters

## DYNAMIC EXPANSION

of the rivet shank is the answer. Greater shank expansion than any other blind fastener. Powerful controlled pull of rivet gun draws stem into rivet shank, *forcibly expanding* rivet to fill hole *tightly*. Joint is strong, tight, permanent.

# HOW *Strong* CAN A BLIND RIVET BE?
# HOW *Tight* CAN A BLIND RIVET BE?

**CHERRY BLIND RIVETING** has stirred up enormous interest since its inception during the war. This remarkable new fastening technique is so *fast* and the results are so *uniformly positive* that it has spread from industry to industry at an astonishing rate. To those who are familiar with the basic characteristics and many possibilities of Cherry Blind Riveting, its virtues are implicit . . . but others, not yet having experienced its advantages, still wonder about certain basic questions. Strength and tightness, for example.

**Tight, Strong Joints** — There are three types of Cherry Blind Rivets. The *self-plugging type* is comparable in strength to solid rivets and is recommended for structural applications. The *pull-through hollow* type is for tight, rigid joints on non-structural jobs. The *regular hollow* is a tacking rivet that clinches very tightly.

**Cherry Blind Rivets** have (a) greater shank expansion and (b) greater allowable variance in material thickness . . . than any other blind fastener. This means uniformly tight, strong joints under actual shop conditions where hole sizes and sheet thicknesses cannot always be controlled closely.

High-strength, self-plugging type Cherry Blind Rivet.

Tight-clinching, pull-through hollow type Cherry Blind Rivet.

CHERRY RIVETS. THEIR MANUFACTURE & APPLICATION ARE COVERED BY U. S. PATENTS ISSUED & PENDING

**Cherry Rivet Company**
LOS ANGELES 13, CALIFORNIA

Get this Illustrated Manual. Write to Dept. B-120, Cherry Rivet Company, 231 Winston Street, Los Angeles 13, Calif.

uring device that does not require tuning.

*Resistive Termination*

Two difficulties arise in the termination of a transmission line with a resistor; power dissipation in the resistor, and correct matching of the resistor to the transmission line. The power dissipated in the resistor may be found from a measurement of temperature rise, voltage or current. Of the three, voltage measurement is the most convenient but the capacitive input of the voltmeter must then be compensated to obtain effective resistive termination of the transmission line.

For the termination, one type of resistor is of particular interest, a ½-watt carbon resistor having brass endcaps and contained in a ceramic case. The length of the carbon mix between brass caps is 0.5 cm, the diameter 0.3 cm.

Assuming a resistor of 50 ohms with these dimensions, the resis-

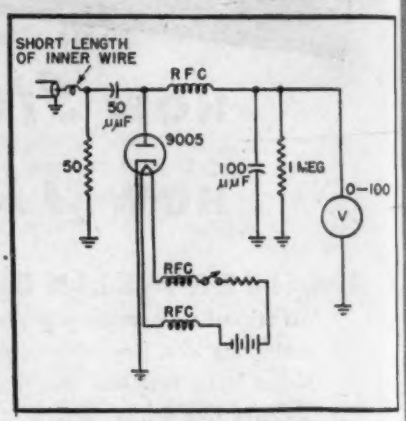



FIG. 1—Circuit of vhf wattmeter

tance per cm cube is seven ohms and the skin depth is 0.6 cm. The skin effect may thus be neglected as we can expect substantially uniform current distribution.

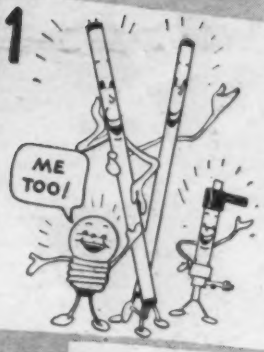
Knowing the current distribution enables us to determine the inductive effect of the resistive rod, a value of 0.001 microhenry or an inductive reactance of 2.5 ohms at 500 mc. Thus the terminating impedance gives a standing wave ratio of 1.05 on the transmission line. Sufficiently accurate power measurements may be made when the standing wave ratio is less than 1.1, a value rarely achieved even with the best antenna designs.

The 9005 diode having a resonant

# Are you in the know on GLOW?

**THESE QUICK FACTS ON G-E NEON GLOW LAMPS MAY HELP YOU PRODUCE A MORE SUCCESSFUL PRODUCT**

1




**QUESTION**—What is a neon glow lamp? What makes it glow?

**ANSWER**—It is the "baby" of the electrical discharge lamp family—and consists of twin electrodes sealed within a bulb containing neon gas. When the gas is ionized by application of a voltage, an orange-red glow covers the cathode.

2

**QUESTION**—How are glow lamps used?

**ANSWER**—They're ideal as indicators. Such applications include annunciators, control panels, electrical appliances, testing devices, warning signals, pilot lights. Glow lamps also provide a source of low illumination for night lights, exit lights, dial lights, etc.

3

**QUESTION**—What are the main advantages of glow lamps from the product designer's standpoint?

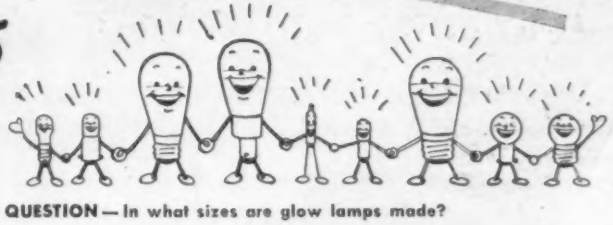
**ANSWER**—(a) Distinctive orange-red glow—high visibility.
(b) Dependable performance and long life—rated at 3000 hours.
(c) Very low current consumption—as little as 1/25-watt.
(d) Low brightness, low heat.
(e) High resistance to shock and vibration.
(f) Can be installed in small space.
(g) Operate directly from regular 105-125, and 210-230 volt circuits, a-c or d-c.

4

**QUESTION**—How does voltage affect glow lamp application?

**ANSWER**—Glow lamps need a certain minimum starting voltage. Their use is not recommended below 105 volts, but there is no upper voltage limit if resistors are provided.

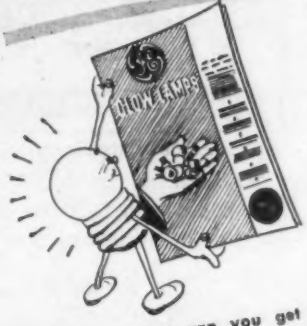
5



**QUESTION**—In what sizes are glow lamps made?

**ANSWER**—General Electric makes a complete line of neon glow lamps, in a wide variety of miniature bulb sizes, and in wattages from 3 watts to 1/25 watt, with both screw bases and bayonet bases.

6



**QUESTION**—Where can you get full information on G-E Neon Glow Lamps and their application to your product?

**ANSWER**—Write to Nela Specialty Division, Lamp Dept., General Electric Company, 1 Newark Street, Hoboken, N. J.

# G-E LAMPS

**GENERAL ELECTRIC**

*Nela Specialty Div. Lamp Dept., 1 Newark St., Hoboken, N. J.*

WRITE FOR YOUR COPY TODAY!

**Akra-Ohm Resistors**
Accurate Fixed Wire Wound Types

*This New Bulletin tells you what you want to know about*

# ACCURATE FIXED WIRE WOUND RESISTORS

DIMENSIONAL SPECIFICATIONS · MOUNTING AND TERMINAL DESIGNS · POWER DISSIPATION · TEMPERATURE COEFFICIENT OF RESISTANCE · MAXIMUM RESISTANCE CHARTS · RESISTANCE ALLOYS · MOISTURE AND FUNGUS PROOFING · HERMETIC SEALING

*Shallcross Types Designed to Meet JAN-R 93 Specifications*

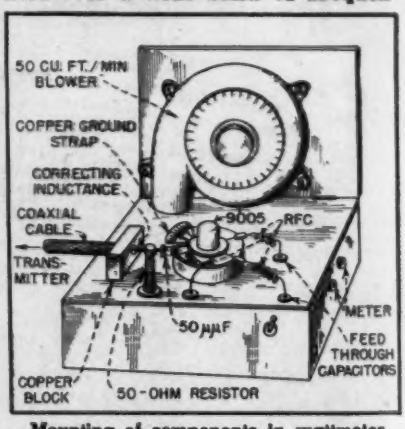
**SHALLCROSS MFG. CO.**
DEPT. E-27 COLLINGDALE, PA.
ENGINEERING · DESIGNING · MANUFACTURING



frequency of 1,500 mc and a voltage rating of 117 volts maximum makes a peak diode voltmeter for the measurement of voltage across the resistor. For the moment we are concerned with the input capacitance of this diode and, allowing for socket and stray capacitance, a value of one $\mu\mu$f may be assumed. The mismatch due to this capacitive reactance may be neutralized by a corresponding inductive reactance.

The shunt capacitive reactance may be converted to an equivalent series reactance of three ohms at 200 mc for which the equivalent inductance is 0.002 microhenry. Difficulties in making a completely noninductive connection to the transmission line are now avoided as we may leave a short length of the inner conductor equivalent to this value for making the connection to the resistor. With RG-8/U 50-ohm concentric cable, having a 7/21 copper conductor, the length of conductor is approximately 0.5 cm from the end of the cable to the resistor.

With the relatively small values of correction used the slope of the inductive and capacitive reactance curves may be assumed to be constant so that the compensation will hold over a wide band of frequencies, certainly from 100 to 500 mc. The correction is made in approximately the middle of this band.




**Mounting of components in wattmeter**

*Accuracy*

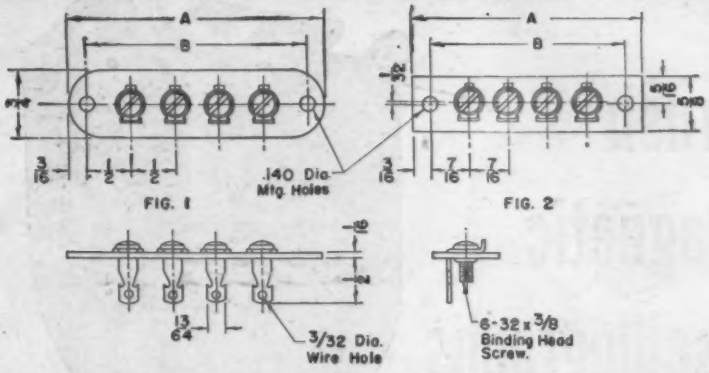
With a high resistance load, one megohm, and a small r-f bypass capacitor of 100 $\mu\mu$f, the meter reading will indicate peak voltage across the terminating resistor. Because of electron transit time and internal diode resonance, the meter indication at 500 mc will be a few

# EBY TERMINAL STRIPS

## TYPE TS-56

**Screw Type. For applications where wires must be attached and detached quickly and conveniently at intervals. Supplied plain or marked to customers' specifications. Also available with Knurled Head screws.**

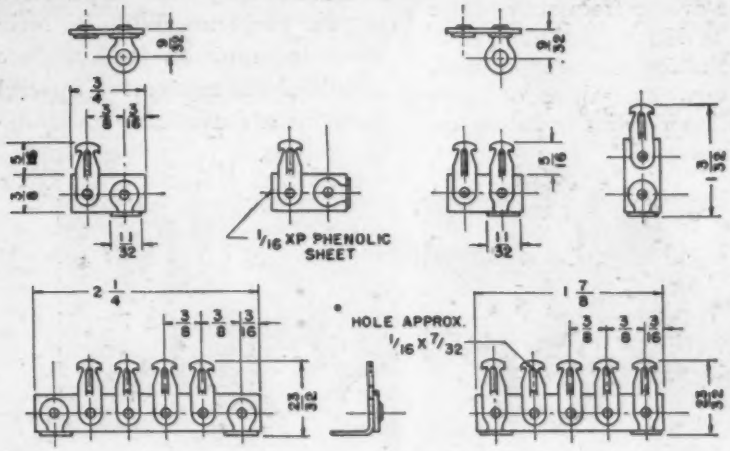
**Contacts—Brass, cadmium plated**
**Screws—Steel, cadmium plated**
**Plates—1/16" XP Phenolic sheet**

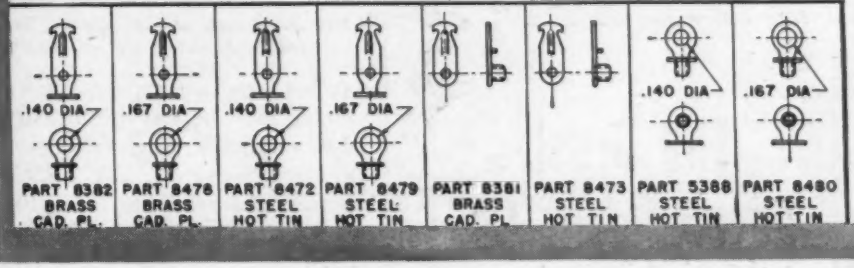



| FIGURE NO. | CATALOG NO. BINDING HEAD SCREW | CATALOG NO. KNURLED HEAD SCREW | NO. OF TERMINALS | OVERALL LENGTH 'A' | MTG. HOLES CENTERS 'B' |
|---|---|---|---|---|---|
| 1 | 8513 | 8523 | 1 | 1 3/8 | 1 |
| 1 | 8514 | 8524 | 2 | 1 7/8 | 1 1/2 |
| 1 | 8515 | 8525 | 3 | 2 3/8 | 2 |
| 1 | 8516 | 8526 | 4 | 2 7/8 | 2 1/2 |
| 1 | 8517 | 8527 | 5 | 3 3/8 | 3 |
| 1 | 8518 | 8528 | 6 | 3 7/8 | 3 1/2 |
| 1 | 8519 | 8529 | 7 | 4 3/8 | 4 |
| 1 | 8520 | 8530 | 8 | 4 7/8 | 4 1/2 |
| 1 | 8521 | 8531 | 9 | 5 3/8 | 5 |
| 1 | 8522 | 8532 | 10 | 5 7/8 | 5 1/2 |
| 2 | 8706 | 8711 | 1 | 1 1/4 | 7/8 |
| 2 | 8710 | 8712 | 2 | 1 11/16 | 1 5/16 |
| 2 | 8610 | 8713 | 3 | 2 1/8 | 1 3/4 |
| 2 | 8707 | 8714 | 4 | 2 9/16 | 2 3/16 |
| 2 | 8708 | 8715 | 5 | 3 | 2 5/8 |

## TYPE TS-58

**Tie Point. Used throughout industry for tying in a wide variety of components. Available in any combination of terminals or brackets as shown up to and including 14. Holes are spaced 3/4" apart with 3/16" between end holes and edge of board. Terminals available with elongated hole for threading or notched for wrap-around assembly. Plates are of XP Phenolic sheet.**

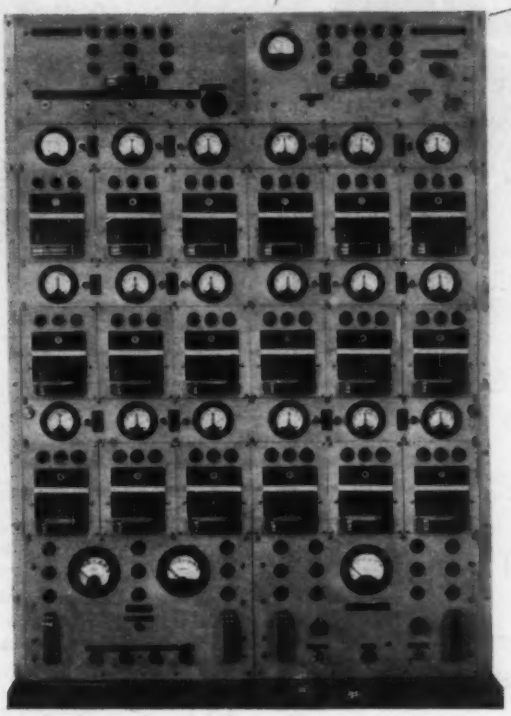



**HUGH H. EBY INCORPORATED**

**18 West Chelten Avenue**
**Philadelphia 44, Pa.**

# AN ANNOUNCEMENT ON TELEMETERING

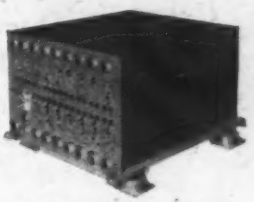


Complete Ground Receiving Equipment, Front Panel

The makers of famous war proved NDRC Type II Model A telemetering system are now in a position to supply this and other tried and proven systems for your particular use.

The same engineers who designed and engineered this system are now available to assist you on your telemetering problems.

*Licensed manufacturers NDRC Type I Model B, Type II Model A, and other telemetering systems.*



Airborne Transmitter Commutator

## RADIO ENGINEERING PRODUCTS

A DIVISION OF RAYMOND ROSEN & CO., INCORPORATED

32ND & WALNUT STS., PHILADELPHIA 4, PA.

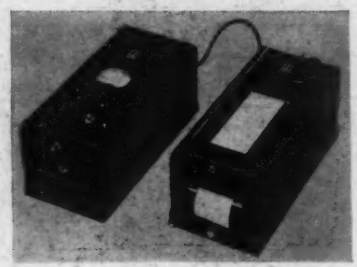
# Brush Magnetic Oscillographs

***make direct-writing recordings of strains and pressures instantaneously!***

*The remarkable new Brush Magnetic Recording Pen Motor—heart of the Brush Direct-Inking Oscillograph. Highly stable. May be used under virtually any climatic or temperature conditions. Exceptional accuracy.*

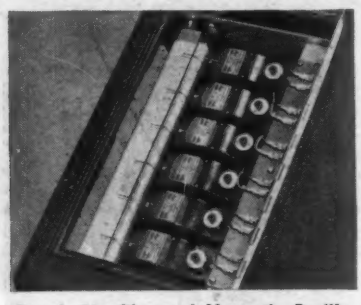
*Instantaneous, permanent, ink-on-paper* recordings by Brush Oscillographs make their use almost unlimited. Accurate recordings of strains, pressures and countless electrical phenomena can be made over a frequency range of D.C. to 100 c.p.s. Either A.C. or D.C. circuits can be measured. Whenever desired, recordings may be stopped for notations on chart-paper.

Brush Oscillographs are compact, portable and ruggedly constructed for ease of handling and operation. Investigate them now. Brush engineers will gladly co-operate in determining their application to your problems. Write for technical information for complete details of this equipment. Special bulletins are available on strain-gauge use.



*Brush Single-Channel Magnetic Oscillograph with amplifier. Especially suited for strain-gauge applications, counting, surface analysis and similar applications. Three-speed paper drive, 5, 25, 125 mm per second. Chart paper 2⅜" wide.*

*Brush Double-Channel Magnetic Oscillograph for use where two simultaneous recordings are desired—as in synchronizing problems. Three-speed paper drive, 5, 25, 125 mm per second. Chart paper 3 15/32" wide. Rugged construction.*



*Brush Six-Channel Magnetic Oscillograph. Excellent for strain-gauge recordings. Dust-proof case. Interchangeable gear paper drive. Your choice of paper speeds from ⅛" to 5" per second. Chart paper 12" wide. Compact design.*

## The Brush Development Co.

**3415 PERKINS AVENUE**
**Cleveland 14, Ohio**

*Canadian Representatives:*
*A. C. Wickman, (Canada) Ltd.,*
*P. O. Box 9,*
*Station N, Toronto 14*




percent low with correspondingly less error at lower frequencies. This error has been described as the premature cutoff error and is dependent on the characteristics and geometry of the tube.

Diode resonance is caused by the series inductance of the tube leads resonating with the plate-to-cathode capacitance. Resonance checks are best made by a variable-frequency signal generator as unavoidable external lead inductance will lower the resonant frequency of the diode. Resonance with the 9005 may thus occur at 1,000 mc. At 500 mc, the meter indication may be 30 percent high, at 100 mc the error will be one percent. A calibration chart may be made covering the band.

### *Construction Details*

To aid heat dissipation in the resistor, the diode assembly may be placed on a copper plate to which the resistor is soldered using an ample supply of metal. This ensures good thermal and radio conductivity. With an air blower supplying 50 cu ft/min to the copper plate, the resistor may be operated at ten or twenty times its normal rating in free air or much higher for short periods.

Figure 1 shows the wiring arrangement of the diode power head. Use of a battery for heater power

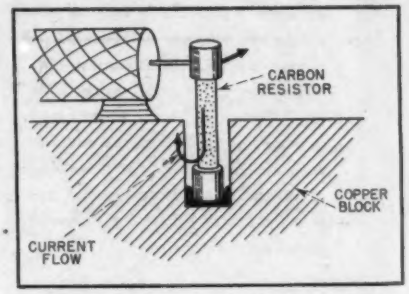



**FIG. 2—Method of reducing the effective inductance of a carbon resistor**

avoids long a-c supply leads. The meter may be any high-resistance d-c voltmeter, preferably with a multiplier switch. For peak pulse power measurements the voltmeter may be replaced by a calibrated oscilloscope.

If large resistors introduce error because of excessive inductive reactance, the resistor may be sunk in a hole in the copper as shown in Fig. 2 to provide reversal of current in the restricted area.

# The Rauland VISITRON 10FP4/R6025

## . . . the NEW Picture Tube with Unprecedented Brilliance

No Ion Trap Required

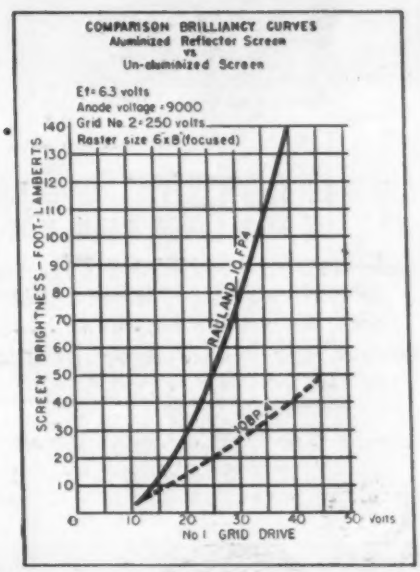
Virtually Flat Face

Direct Viewing

**NEW!**
**ALUMINIZED REFLECTOR-SCREEN**

Doubles the Brilliance
Highlight: 75 Foot Lamberts (avge.)
Contrast Range: Over 100 to 1
No Ion Spot—No Cathode Glow

| *Specifications of the Rauland Visitron 10FP4/R6025* | |
|---|---|
| Heater Voltage | 6.3 A.C. or D.C. |
| Focusing Method | Electromagnetic |
| Deflection | Electromagnetic |
| Deflection Angle | 50 Degrees |
| Screen | Phosphor P4<br>Aluminized Reflector |
| Bulb Diameter (Max.) | 10⅝" at screen end |
| Length | 17⅝" ± ⅜" |
| Base | Small Shell Duodecal 7 Pin |
| Anode Terminal | Cavity |
| Anode Volts (Max.) | 13,000 |
| Anode Volts (Operating) | 9,000 |
| External Coating (Optional): 500 mmf. | |




• WRITE FOR INTERESTING BULLETIN •

RADIO • RADAR • SOUND • **Rauland** COMMUNICATIONS • TELEVISION

*Electroneering is our business*

THE RAULAND CORPORATION • CHICAGO 41, ILLINOIS

ATTENTION
INSTRUMENT
MANUFACTURERS

File your rectifier specifications with Conant Now!!

"Specials" have always been a Conant specialty
Conant designs and laboratory production methods permit the production of special rectifier assemblies at regular prices.
If your specifications are on file at Conant, you can be sure of receiving rectifiers which will fit the job.
Your specifications must contain the following information:

1 The maximum range of forward resistance at a definite value of current.
2 The maximum inverse current per disc.
3 The ambient temperature at which above values are to be measured.
4 A definite statement of the method used to make the above measurements and a schematic of your test circuit.

The above can then be interpreted to fit Conant test methods.

CONANT ELECTRICAL LABORATORIES
*Instrument Rectifiers*
6500 O STREET, LINCOLN 5, NEBRASKA, U. S. A.

20 Vesey St., New York 7, New York
85 E. Gay St., Columbus, Ohio
600 S. Michigan Ave., Chicago 5, Ill.
1215 Harmon Pl., Minneapolis 3, Minn.
518 City Bank Bldg., Kansas City 8, Mo.
1212 Camp St., Dallas 2, Texas
3781 Boulevard N. E., Atlanta, Ga.
4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
Export Div., 75 West St., New York 6, N.Y.
50 Yarmouth Rd., Toronto, Canada

 (continued from p 140)

ing the rate at which chloropicrin gas penetrated a tube filled with charcoal adsorbent. Note the complete removal of the gas up to the time when the "break" occurred, when chloropicrin began to pass through the charcoal in significant quantities.

Figure 4 illustrates a continuous record of phosgene concentrations obtained on the desert in Utah on the occasion of the bursting of a 1,000-lb bomb charged with phosgene. Note the amazingly rapid fluctuations in concentration which the ultraviolet photometer was able to resolve.

The dashed line demonstrates the response of a conductivity gas analyzer, an analyzer which measured the phosgene concentration by measuring the electrical conductance of water in which the phosgene was continuously dissolved. This method missed most of the details of the phosgene concentration fluctuations.

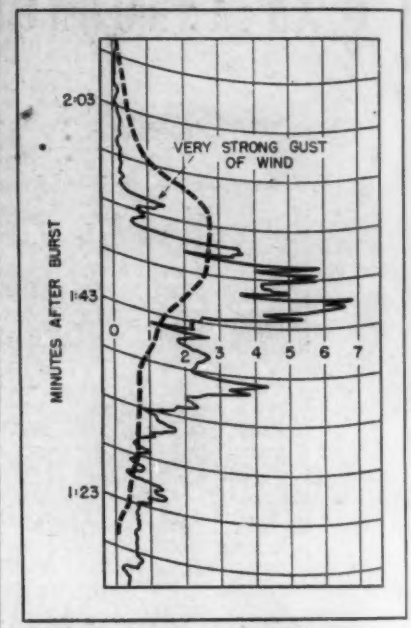



**FIG. 4—Automatic record of phosgene concentration obtained downwind from the burst point of a 1000-lb. bomb charged with phosgene. The dashed line shows the response of a conductivity gas analyzer**

The two examples cited are typical applications to practical problems. Other analogous possibilities readily suggest themselves. In the design of large-scale reactors in chemical-engineering processes, information on smaller models is generally required. For example, in evaluating the performance of adsorbent beds in solvent recovery or

CORWICO

WIRES

*at work*

*Photo courtesy of EMERSON Radio & Phonograph Corp.*

**WHY ARE CORWICO WIRE PRODUCTS SPECIFIED BY THIS LARGE RADIO MANUFACTURER?**

**Because their ENGINEERING Department values their faithful performance of the requirements of insulation resistance and voltage breakdown . . .**

**Because their PRODUCTION Department finds that they possess the essential qualities which permit easy pushback or mechanical stripping . . .**

**Because their PURCHASING Department finds that these quality products, backed by dependable service, are sold at prices that spell true economy . . .**

CORNISH WIRE CO., INC.

15 Park Row • New York City, 7



toxic-gas protection, the ultraviolet photometer is particularly convenient when substances such as acetone, butadiene, benzene or phosgene, with ultraviolet-absorbing properties, are under study. Similarly, it is frequently necessary to have a constant check on the concentration in air of volatile materials in various industrial processes, and for this purpose the automatic-recording apparatus is especially suitable.

In addition the ultraviolet photometer has proved convenient in investigations of a number of fundamental scientific problems. It has been used, for example, in a study of the rate of conversion of NO into $NO_2$. Similarly it is now being applied to an investigation of the kinetics of the decomposition of hydrogen peroxide. In general it is applicable to any problem requiring the analysis of a substance which absorbs ultraviolet radiation.

## Electronic Drive for Printing Presses

THE *Philadelphia Inquirer* is the first newspaper to install a new type of electronic drive for increased flexibility, minimum speed variation with load, and maximum efficiency over a wide range of operating speeds. It will be applied to 61 rotogravure and 44 newspaper press units at the new plant of the newspaper.

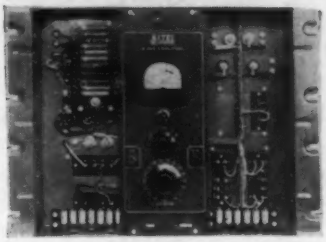
The drive system operates directly from a 440-volt plant circuit and consists of a sealed-ignitron tube panel and a magnetic control panel, motor selector switches, and the necessary d-c drive motors. Except for the drive motors, the equipment is completely static. This contributes to compactness, eliminates the necessity of special foundational and structural supports, and facilitates incorporation with modern load-center power distribution equipment.

With this new General Electric drive, especially adapted for use with high-speed rotary web presses, adjustable voltage is supplied to adjustable-speed d-c drive motors which may be mounted coaxially with the main shaft of the press. Stepless speed control—including jogging, slow threading speed,

# Testimonials

***without adjectives***

**One good way to raise the eyebrows of progressive engineers is to have other leaders in the industry utilize your product. A singular piece of equipment like the Altec Lansing Intermodulation Analyzer can't be bought on the basis of glib recommendation. You should be convinced of its magnitude by application to your own problem . . . or by study the names of the organizations where it is now in use.**

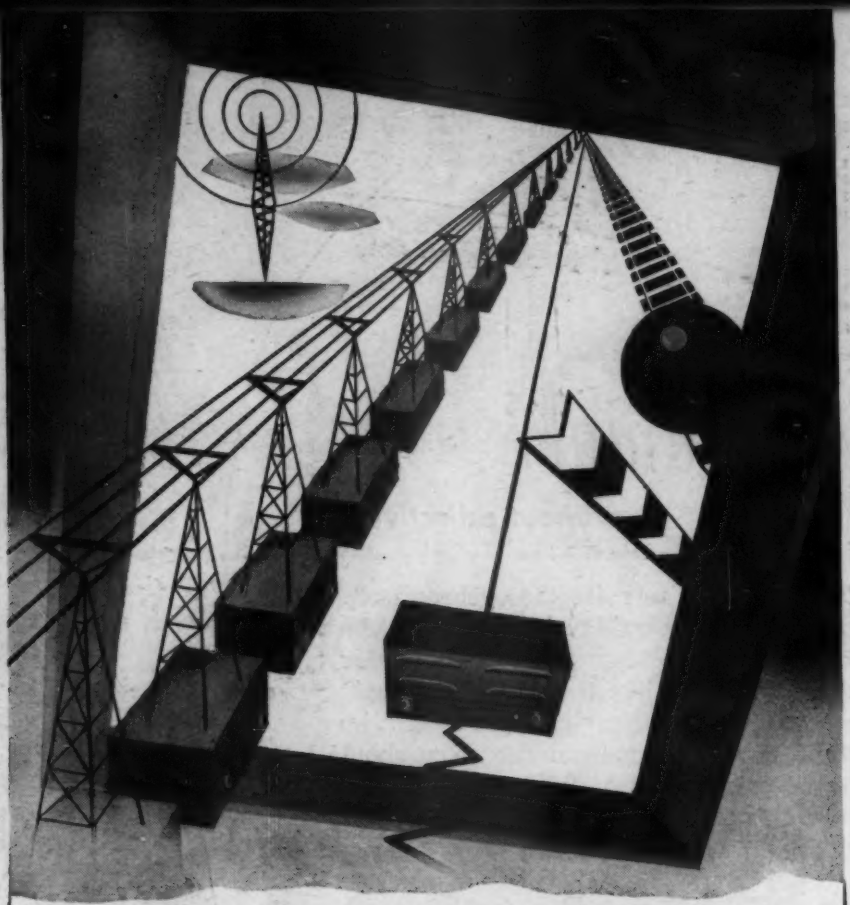


**SEE THE ALTEC LANSING INTERMODULATION ANALYZER AT THE I. R. E. SHOW.**

**Originally developed for film studios, the Altec Lansing Intermodulation Analyzer is rapidly being adopted by broadcasting and recording studios as well as sound research laboratories. It supplements present methods of checking audio-distortion where quick and frequent intermodulation checks are necessary to maintain low distortion in high quality systems.**

**ALTEC**
**LANSING CORPORATION**
1161 N. Vine St., Hollywood 38, Calif.
250 W. 57th St., N. Y. 19, N. Y.

**"KEEP ADVANCING WITH ALTEC LANSING"**



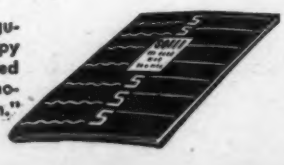
A MILLION MILES
OF STRAIGHTENED VOLTAGES
*Without Moving a Muscle*

**Sorensen Voltage Regulators guarantee many miles of speed with safety by constantly and automatically stabilizing voltages that operate vital communications equipment on surface and air transportation lines.**

**Wire and radio contact systems depend upon quick, accurate response to even the smallest variation to attain peak performance. No moving parts in a voltage regulator means no time consuming adjustments, no wear and a minimum of maintenance.**

**These are just a few reasons why Sorensen Voltage Regulators are chosen as the perfect power guardian for the millions of miles of communications so essential to safe transportation.**

Investigate the many advantages of Sorensen regulators applied to your unit. Write today for your copy of the new, complete Sorensen catalog M-L. It is filled with schematic drawings, performance curves, photos and contains in detail, "Principles of Operation."



SORENSEN & COMPANY, INC.
STAMFORD, CONNECTICUT

A LINE OF STANDARD REGULATORS FOR LOAD RANGES UP TO 30 KVA.
SPECIAL UNITS DESIGNED TO FIT YOUR UNUSUAL APPLICATIONS.



acceleration, deceleration, and dynamic braking—is provided without the necessity of speed-regulating resistors or auxiliary starting motors. The drive is operated by conventional push-button stations, including an emergency control station and an automatic safety signal system.

## Simple Foolproof Production Tester

by MARTIN F. BEAVERS
*General Electric Company*
*Pittsfield, Massachusetts*

ENGINEERS who have qualms about having sensitive equipment used by nontechnical workers doing production-line testing can substitute the device to be described in a dozen applications where use of extremely accurate and expensive instruments is not warranted.

The voltmeter covers a range from approximately 50 to 500 volts, a-c or d-c, and employs only a 500,000 ohm potentiometer and a small neon lamp. Instead of using the brilliance of the neon lamp as an indication of the voltage, the voltage is read from a scale on the instrument. Figure 1 shows the voltmeter circuit but because of its simplicity, no detailed construction information is deemed necessary.

Operation is based on the inherent characteristic of a neon glow lamp that a certain voltage is necessary to make it glow. In most neon lamps, this ignition voltage may vary slightly from one applica-

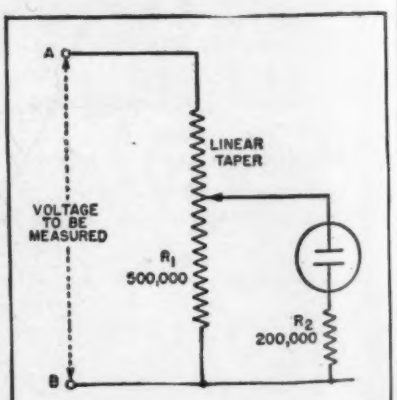



**FIG. 1.—A potentiometer having a linear change of resistance versus rotation and a neon lamp form the foolproof voltmeter**

ELECTRICAL

# Mitchell-Rand

INSULATION HEADQUARTERS

SINCE 1889

# VARNISHED TUBINGS

FIBERGLAS and STAPLE FIBER COTTON YARN

## meet or exceed SPECIFICATIONS

*set by*

VARNISHED TUBING ASSOCIATION

*and*

AMERICAN SOCIETY FOR TESTING MATERIALS

**M-R FIBERGLAS** *(INORGANIC)* **VARNISHED TUBINGS are made in four grades: Standard; Double Saturated; Triple Strength and Impregnated.**

**STANDARD GRADE** for maximum flexibility, has little varnish and is recommended for high temperatures where dielectric strength is not a factor.

**DOUBLE SATURATED** has all qualities of the Standard Grade but with additional coats of varnish to bring the dielectric rating up to 1500 volts.

**TRIPLE STRENGTH** is built up with coats of especially flexible insulation varnish for dielectric ratings up to 2500 volts and is particularly suited where assembly operations include the possibility of rough handling.

**IMPREGNATED** is the Optimum in Superiority for high gloss, non-hydroscopic, resistance to high temperatures, oils, acids, etc. IMPREGNATED has a dielectric rating beyond 7000 volts and is unequalled for Long Life Under Most Severe Conditions. *Write For Samples.*

**FOR USERS OF COTTON YARN VARNISHED TUBINGS** The Mitchell-Rand MIRAC and HYGRADE Varnished Tubings of long staple fiber yarn are comparable to Fiberglas Tubings in dielectric ratings, tensile strength, flexibility and long life. *Write For Samples.*

**MITCHELL-RAND** in its improvement of Varnished Tubings, took as its starting point the specifications established by the Varnished Tubing Association and the Society for Testing Materials . . . and today produces Varnished Tubings that meet or exceed the known specifications for Dielectric, Tensile Strength, Flexibility, Non-Fraying, High Gloss, Non-Hydroscopic Resistance to High Temperatures, Oils, Fats, Acids, etc.

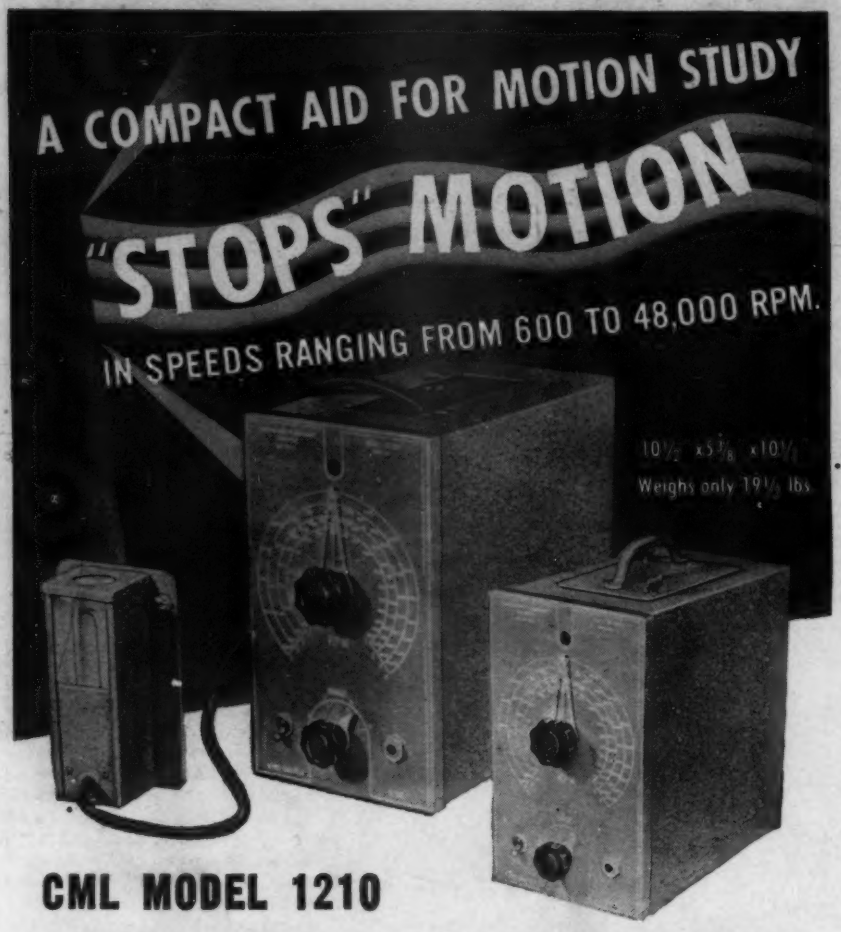
Write today for your free copy of the M-R WALL CHART with its engineering tables, electrical symbols, carrying capacities of conductors, dielectric averages, thicknesses of insulating materials, tubing sizes, tap drills, etc.

## MITCHELL-RAND INSULATION COMPANY, INC.

51 MURRAY STREET COrtlandt 7-9264 NEW YORK 7, N.Y.

A PARTIAL LIST OF M-R PRODUCTS

Fiberglas Varnished Tape and Cloth
Insulating Papers and Twines
Cable Filling and Pothead Compounds
Friction Tape and Splice
Transformer Compounds
Fiberglas Saturated Sleeving, Varnished Tubing
Asbestos Sleeving and Tape
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth, Tubing
Fiberglas Braided Sleeving
Cotton Tapes, Webbings and Sleevings
Impregnated Varnish Tubing
Insulating Varnishes of all types
Extruded Plastic Tubing




**CML MODEL 1210**

# PORTABLE STROBOSCOPE

*This newly developed stroboscope* employs a novel circular arrangement, using a self-blocking oscillator. Rotary or vibratory motion can be "stopped" when the moving object is examined with stroboscopic light source. The speed covered is from 600 to 48,000 RPM (10-800 CPS), in 4 ranges. A synchronized reed is provided for accurate calibration against the line frequency.

*A valuable aid in industry* for the slow-motion study of rotating, reciprocating, or vibratory mechanisms, CML 1210 is also useful for studying mechanical stresses and strains under dynamic conditions.

*The light source* is contained in a probe attached to a 4-foot flexible cable. This unusual feature makes CML 1210 especially useful when using the Stroboscopic light in small out-of-the-way places. The light probe and cable are housed in the cabinet when the Stroboscope is not in use. The handle of the probe is then used to carry the instrument.

*Inquiries Invited. Descriptive Bulletin Available*

**COMMUNICATION MEASUREMENTS LABORATORY**

**120 GREENWICH STREET, NEW YORK 6, N. Y.**

Sales Offices: CHICAGO; 612 N. Michigan Ave—WASHINGTON: 924 19th St., N.W.
PHILADELPHIA: Van Dam Building, 10th and Market Sts.




tion of voltage to another. However, for practical purposes, this variation is relatively small and readings are obtainable within three percent accuracy. Another characteristic of the neon lamp is that once it is ignited, the voltage will have to be lowered somewhat below the ignition voltage in order to extinguish the lamp. Due to the fact that each individual neon lamp may have a slightly different ignition voltage, no definite value can be given; however, ignition voltages of the order of 50 volts a-c or 70 volts d-c may be expected from lamps such as the GE, NE-51, neon glow lamp (resistorless).

When d-c voltage is applied, only one of the two electrodes will glow —the one which is connected to the negative side of the source; thus, polarity may be determined by noting which of the electrodes glows. However, when connected to an a-c source, both electrodes glow.

There may be a slight difference in ignition voltage depending upon which electrode is connected to the negative side of a d-c source. The electrode which has the lowest ignition voltage is preferable, and the meter should be marked with polarity indications; otherwise the calibration may not be correct if the polarity is reversed on d-c measurements.

Other types of neon lamp may be used in this voltmeter circuit. Experimentation with a lamp will enable one to quickly ascertain its particular characteristics. In general, a small wattage lamp is more satisfactory than a large wattage lamp. If the lamp has a protective resistor built into the base, the 0.2

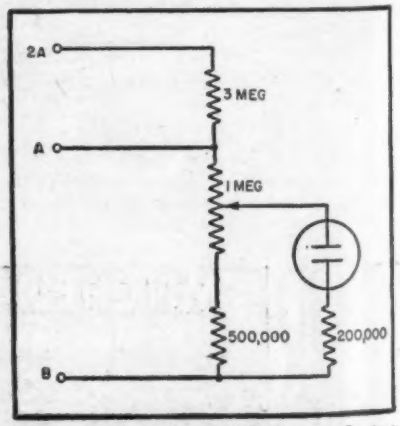
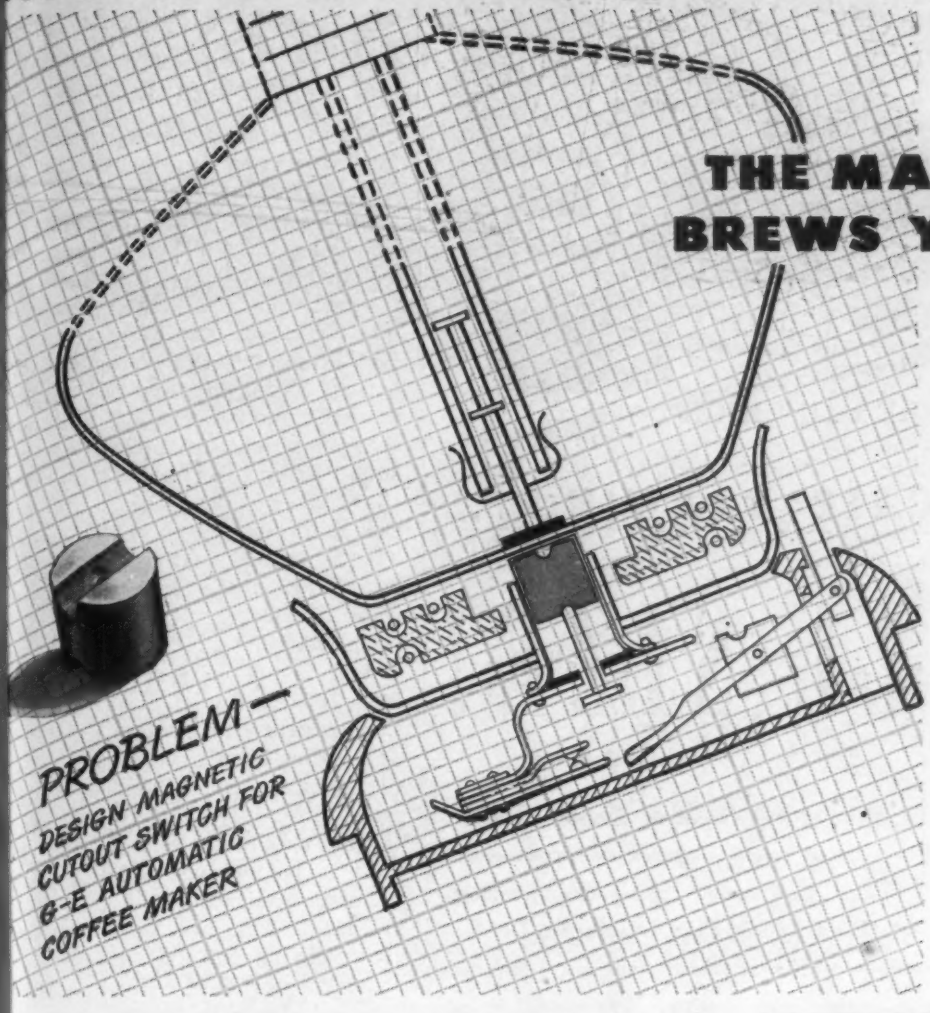
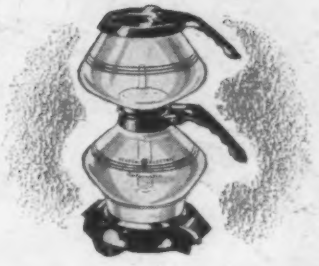



**FIG. 2—Improved readability and two ranges are provided by this circuit**

YOU GET QUALITY PLUS ENGINEERING SERVICE WITH G-E PERMANENT MAGNETS




# THE MAGNET THAT BREWS YOUR COFFEE



The heart of the G-E Automatic Coffee Maker is a tiny but powerful sintered ALNICO 2 magnet. At precisely the right moment, it shuts off the current and the coffee is ready! Pressing the button raises the magnet to the position shown, where it is held by attraction through glass to the nickel disc at the bottom of the siphon tube. When enough pressure is developed, boiling water surges up the tube, pulling the disc assembly with it. Its top magnetic support gone, the ALNICO magnet drops and opens the contact switch.

G.E.'s precise quality control methods used throughout magnet production, plus accurate testing and rigid inspection assure you of receiving magnets of the highest uniform quality for your application.

Greater flexibility of magnet design is possible with the many G-E permanent magnet materials now available. The large group of sintered and cast ALNICO alloys has been augmented by the lightweight, non-metallic mixture, VECTOLITE, and by the ductile permanent magnets, CUNICO, CUNIFE and SILMANAL. From such a wide choice of materials, you may now find a magnet better suited for your application or a material which will make possible new designs heretofore impractical or impossible.

General Electric engineers, backed by research and application experience, have acquired years of "know-how" in selecting the best permanent magnet material and properly designing magnets for thousands of products. These engineers are at your service.

For detailed information about G-E permanent magnet materials, fill out and return the coupon to *Metallurgy Division, Chemical Dept., General Electric Co., Pittsfield, Mass.*

**PERMANENT MAGNETS**

**GENERAL ELECTRIC**

CD47-JA2

**ELIMINATE YOUR MAGNET SUB-ASSEMBLY PROBLEMS**

Consult General Electric for the design and manufacture of carefully calibrated permanent magnet sub-assemblies, ready for your final product. G-E magnet sub-assemblies will benefit you in the following ways:

- *Eliminate your assembly line rejects.*
- *Eliminate calibration problems in your factory.*
- *Eliminate cost of production and testing equipment.*
- *Eliminate breaking and chipping losses on brittle magnetic materials.*
- *Eliminate expense of shipping special trays for semi-finished magnets.*

We shall be glad to send you additional information about G-E permanent magnet sub-assemblies upon request.

**METALLURGY DIVISION**
**CHEMICAL DEPARTMENT**
**GENERAL ELECTRIC COMPANY**
**PITTSFIELD, MASS.**

Please send me your bulletin, GES-3337A, "Permanent Magnet Materials."

NAME.....

TITLE.....

COMPANY.....

ADDRESS.....

CITY..... STATE.....

$\frac{13}{16}$" SQUARE x 1$\frac{13}{16}$" HIGH

**NOT A SCALE DRAWING...**

# IT'S FULL SIZE!

**Though small in size, this I.F. Transformer by Wright & Weaire gives the perfect performance and is ideal when layout space is limited as in 'personal' receivers, "Walkie-Talkie", and similar equipment. It packs complete reliability into its small compass — $\frac{13}{16}$" square by 1$\frac{13}{16}$" high. Constructed of the finest materials, allied to up-to-the-minute production technique, it will pass all tests. Write to-day for full details . . . they're interesting. Prompt deliveries can be guaranteed.**

**SPECIFICATION**

Primarily designed for use with valves of the I.R5, I.T4 and I.S5 Series. High gain and selectivity with stability are obtainable. Permeability tuning is employed with enclosed type cores and the necessary fixed condensers 'built in'. Coils are impregnated and can be used with confidence in the tropics. Available in the following preferred frequencies with various degrees of coupling :—460 Kc/s, 1.6 Mc/s, 2.1 Mc/s, 4.86 Mc/s. The response curve shown is for Type M400 and is typical of the whole series. Nominal frequency is 460 Kc/s but is adjustable from 420 to 530 Kc/s approx.

WEARITE ★

**MINIATURE I.F. TRANSFORMERS**

WRIGHT & WEAIRE LTD., 740, HIGH ROAD, TOTTENHAM, LONDON, N.17, ENGLAND. CABLES: WRITEWEA, LONDON
FACTORY: SIMONSIDE WORKS · SOUTH SHIELDS · CO. DURHAM · ENGLAND

★This Trade Mark is well-known in Britain as that of a Company who are responsible for the Design, Development and Manufacture of Transformers, Vibrators, Switches and Coils. This particular component of real miniature dimensions, yet maintaining highest efficiency, is the latest development of their Engineering Dept. and is backed by 26 years experience in the manufacture of Radio and Electronic components.



megohm resistor shown in Fig. 1 may be omitted.

*Principle of Operation*

As the slide of the potentiometer is moved from terminal *B* toward terminal *A*, the voltage across the lamp increases until a point is reached when the lamp bursts into a glow. Suppose that this point is reached when the slide is just one-quarter of the way from terminal *B*. Then, due to the voltage divider action of $R_1$, the applied voltage across *A* and *B* must be four times that required to ignite the neon lamp. After the lamp has ignited, the divider ratio is upset due to the shunting action of the lamp, but the correct position of the slide is obtained just before the upsetting takes place.

The ohmic value of the potentiometer is not critical. Any value from 100,000 ohms to five megohms should give satisfactory results. The value shown in Fig. 1 was chosen since it provides a meter resistance of 1,000 ohms per volt at the maximum voltage of 500 volts to be measured.

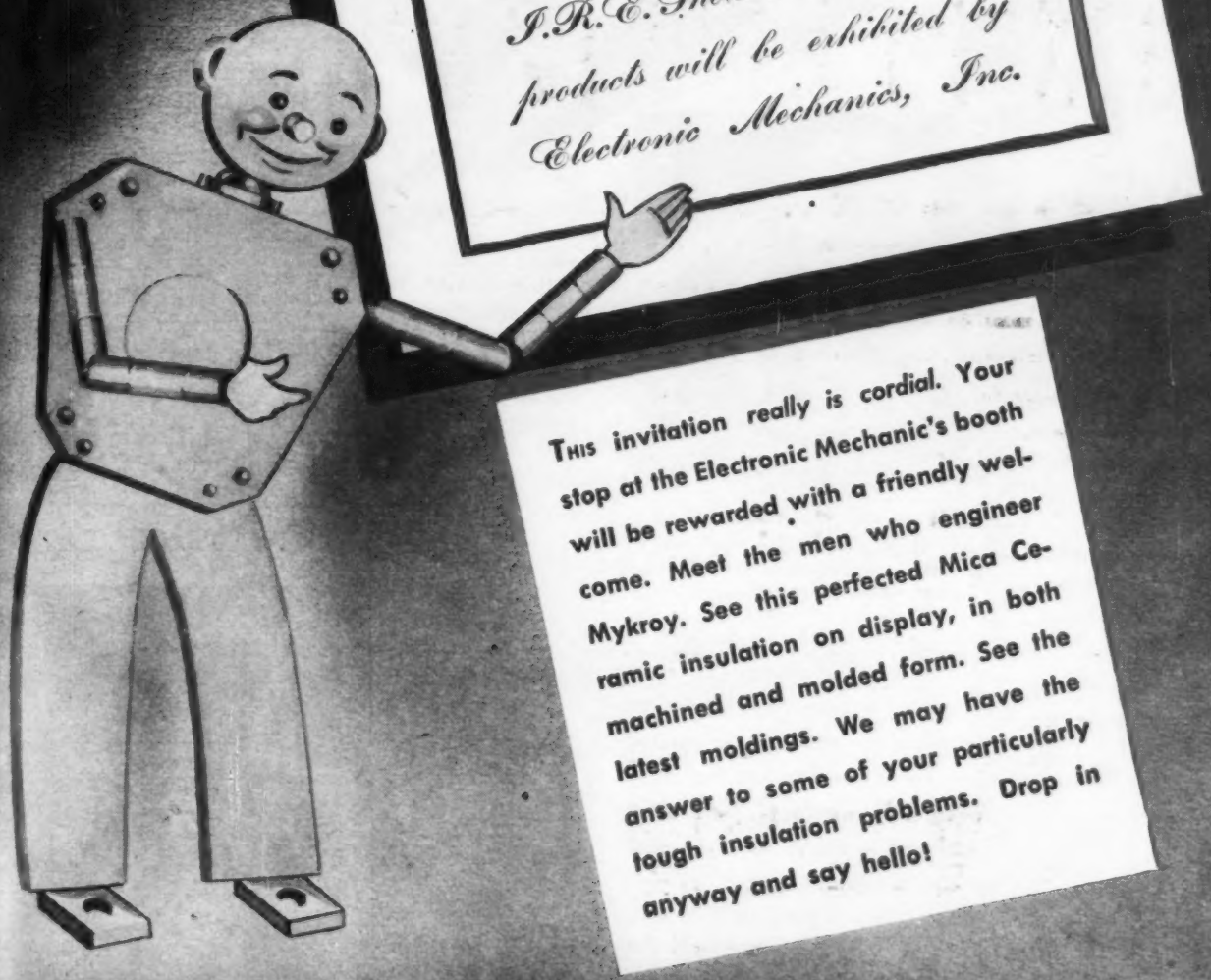
An alternative circuit is shown in Fig. 2. This has the advantage of employing the full use of the potentiometer for voltage indication and also spreads out the readings, especially in the higher voltage part of the scale. If the ignition voltage of the lamp is 70 volts d-c, the voltage range, when applied across terminals *A* and *B*, is 70 to 210 volts; if voltage is applied across terminals 2*A* and *B*, the range is 210 to 630 volts d-c. Other combinations of divider ratio and resistances may be employed.

*Calibration*

This type of voltmeter is a peak-reading instrument and, if the calibration is made with d-c, an a-c scale can be drawn alongside the d-c scale using values equal to 0.707 times the d-c scale values. It is desirable to calibrate with both a-c and d-c if practicable, since a little time lag is inherent in these lamps on alternating current which may produce a small error in the calculated a-c scale.

Having a variable source of known voltages connected across terminals *A* and *B*, and the knob of

# MYKROY *Extends a cordial invitation . . .*

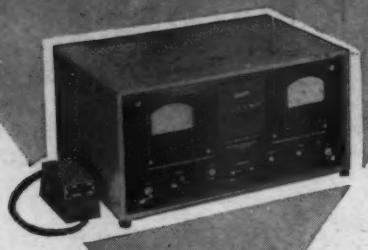

You are cordially invited to visit Booth No. 27 at the I.R.E. Show where Mykroy products will be exhibited by Electronic Mechanics, Inc.

THIS invitation really is cordial. Your stop at the Electronic Mechanic's booth will be rewarded with a friendly welcome. Meet the men who engineer Mykroy. See this perfected Mica Ceramic insulation on display, in both machined and molded form. See the latest moldings. We may have the answer to some of your particularly tough insulation problems. Drop in anyway and say hello!

MYKROY IS SUPPLIED IN SHEETS AND RODS . . . MACHINED OR MOLDED TO SPECIFICATIONS

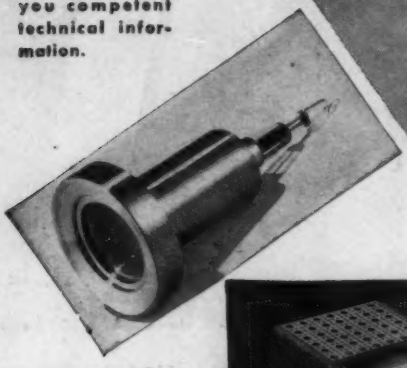
MADE EXCLUSIVELY BY ELECTRONIC MECHANICS INC. 70 CLIFTON BOULEVARD • CLIFTON, NEW JERSEY
Chicago 47: 1917 NO. SPRINGFIELD AVENUE . . TEl. Albany 4310
Export Office: 89 Broad Street, New York 4, N. Y.

Summarizing a few recent developments culminating our twenty-year background in the factual "know how" of instrumentation used in radiation physics.



Have you a radiation measuring problem? Our staff of radiation physicists offers you competent technical information.

Model 337 Geiger - Mueller Counter Scale of 64. Offers a high degree of stability and permanence with a preamplifier and special voltage regulation added features.



Model 311— Geiger - Mueller Tube. Our background in fine tube production offers close reproducibility of tube characteristics.

Model 348 Voltageregulator unit. A bank of seven subminiature voltage regulator tubes arranged in one unit for precision voltage regulation.

Model 338 Electronometer. An electronic instrument which replaces electrostatic electrometers. Input resistance $10^{12}$ Ohms.

This advertisement merely serves to introduce these new instruments and tubes to you. For complete information, prices and deliveries write us and you will receive a prompt reply.

Hi-megohm resistors of stability and accuracy for the difficult applications. Vacuum sealed in glass with special surface treatment. Values 100 to 10,000,000 megohms.

Subminiature electrometer vacuum tubes (actual size) offer an expanding conception of circuit development. Available as:
Diodes
Triodes
Tetrodes
Pentodes

THE VICTOREEN INSTRUMENT CO.
5806 HOUGH AVENUE
CLEVELAND 3, OHIO



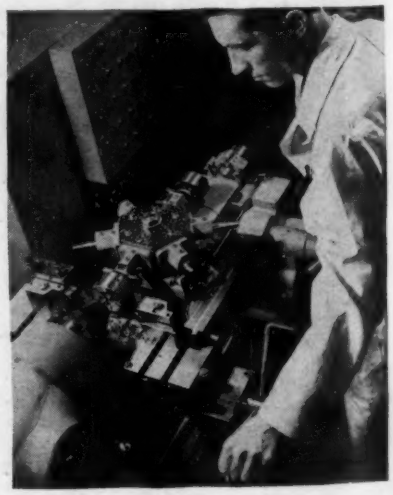
the potentiometer turned to one extreme position so that the moveable contact is at terminal *A*, the applied voltage is raised until the neon lamp glows. This is the minimum voltage which can be measured. The applied voltage is raised in uniform steps, and at each voltage step, the potentiometer knob is turned sufficiently to extinguish the lamp, then turned back until the lamp glows. This position of the knob pointer is marked on a scale.

## Electronic Ignition System

AN ELECTRONIC ignition system for aircraft was produced experimentally at the end of the war by the Bosch firm in Reichenbach, Germany, according to report PB-22653, Office of Technical Services, Department of Commerce. The system is said to eliminate many of the deficiencies of conventional magneto systems.

In the circuit a capacitor is charged through a resistance, and discharged through a grid-controlled tube to the primary of the high tension coil at the spark plug. After completion of the discharge, the grid voltage prevents further passage of current between the anode and the cathode of the tube, thus enabling the capacitor charge to be built up again.

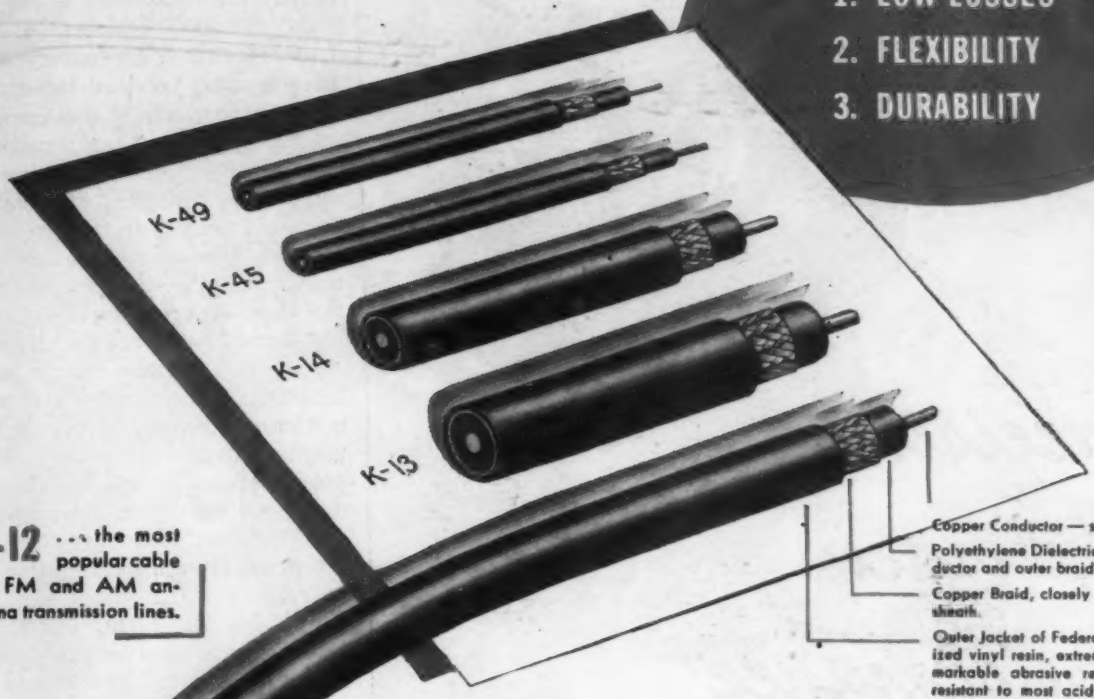
## ELECTRONIC LATHE



Control box and head of 10-inch lathe using electronic control of spindle speed and made by Monarch Machine Tool Company of Sidney, Ohio

# FEDERAL'S *Intelin* HIGH-FREQUENCY COAXIAL CABLES *offer you all three . . .*

1. LOW LOSSES
2. FLEXIBILITY
3. DURABILITY




**K-12** . . . the most popular cable for FM and AM antenna transmission lines.

Copper Conductor — solid or stranded.

Polyethylene Dielectric between central conductor and outer braid.

Copper Braid, closely woven over dielectric sheath.

Outer Jacket of Federal's IN-102, a plasticized vinyl resin, extremely durable with remarkable abrasive resistance, and highly resistant to most acids and alkalis, smoky atmospheres, oils and greases.

INTELIN COAXIAL CABLES are especially designed for high-frequency transmission line service — the vital link between transmitter and antenna.

Their unusually low attenuation losses, obtained by careful selection of dielectrics, conductor spacings, and rigid quality control, assure the most efficient transfer of energy with minimum radiation. They are extra flexible, too — can be bent without cracking at temperatures as low as minus 30°C. Whatever your operating conditions, you'll find that the extra durability of Intelin cables — their outstanding resistance to abrasion, weathering and corrosion — means long uninterrupted service.

Federal's complete line of many sizes and types of coaxial cables enables you to select the *right* transmission line for practically every field of application. Write today for Bulletin D514 giving complete data and specifications.

**PARTIAL LIST OF FEDERAL CABLES COVERING POLICE, BROADCAST AND AMATEUR BAND**

**High-Frequency Coaxial Cable Data**

| Type Number | Characteristic Impedance Ohms | Capacitance Per Ft. mmf | Attenuation Db. Per 100 Ft. | | | | | Power Rating Kilowatts | | | | | Physical Dimensions | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Frequency in Megacycles | | | | | Frequency in Megacycles | | | | | Conductor Dia. | O.D. Over Jacket |
| | | | 1.0 | 1.7 | 30 | 100 | 300 | 1.0 | 1.7 | 30 | 100 | 300 | Solid Copper | |
| K12 | 52 | 29 | .066 | .086 | .425 | .83 | 1.70 | 39 | 30 | 8.50 | 3.0 | 1.5 | .188" | .885" |
| K13 | 52 | 29 | .058 | .076 | .320 | .69 | 1.45 | 51 | 43.8 | 13.5 | 5.4 | 2.3 | .250" | 1.135" |
| K14 | 71 | 21 | .070 | .092 | .460 | .93 | 1.90 | 36.5 | 27.8 | 5.55 | 2.71 | 1.34 | .114" | .885" |
| | | | | | | | | | | | | | Stranded Copper | |
| K45 | 52 | 29 | .155 | .202 | .900 | 2.1 | 4.20 | 13 | 9.9 | 2.4 | .96 | .480 | .086" | .415" |
| K49 | 75 | 20 | .182 | .237 | 1.03 | 2.1 | 3.80 | 9.1 | 6.9 | 2.1 | .79 | .435 | .048" | .415" |

## *Federal Telephone and Radio Corporation*

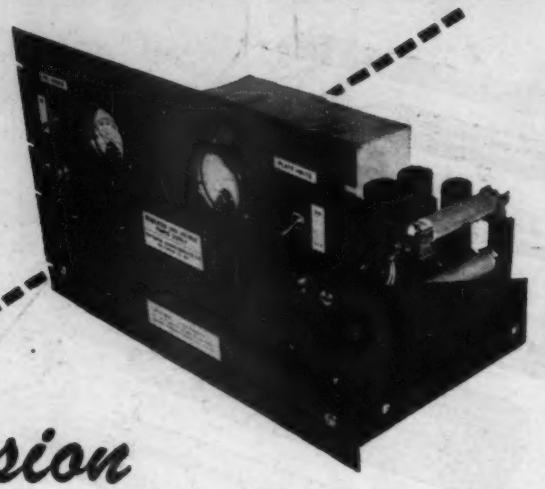
In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal
Export Distributor—International Standard Electric Corporation

An IT&T Associate

Newark 1, New Jersey

* Reg. U. S. Pat. Off.

# Electronic Regulated
## POWER SUPPLIES



* Precision
* Accuracy
* Performance

### SPECIFICATIONS

INPUT—115 v. 50-60 cycle

REGULATION—Less than 1/20 volt change in output voltage with change of from 105-140 V.A.C. input voltage & from NO-LOAD to FULL-LOAD (over very wide latitude at center of variable range)

RIPPLE—Less than 5 millivolts at all loads and voltages

DIMENSIONS—Fits any standard rack or cabinet (overall: 19 in. wide; 12¼ in. high 11 in. deep; shipping wt.—100 pounds)

**TYPE A—VARIABLE FROM 210-335 V.D.C. @ 400 M. A.**
**TYPE B1—VARIABLE—TWO RANGES: 400-600 V. D. C. @ 125 M. A. and 600-890 V. D. C. @ 125 M. A.**

### CONSTRUCTION FEATURES

Weston model 301 (or equal) milliammeter and voltmeter. Separate switches, pilot lights, and fuses for FIL & PLATE VOLTS. All tubes located on shockmount assemblies. Fuses mounted on front panel and easily accessible. Can vary voltage by turning small knob on front of panel. Can modify Type B1 from POSITIVE to NEGATIVE output voltage. Individual components numbered to correspond with wiring diagram.

Rigid construction: components designed to withstand most severe military conditions—physical & electrical; were greatly under-rated. (Adapted to civilian use from RADAR Power Supply RA-57.)

*Tube complement:* Type A: 2-836; 6-6L6; 2-6SF5; 1-VR150; 1-VR105
Type B1: 2-836; 2-6L6; 2-6SF5; 1-VR150; 1-VR105

### IMMEDIATE DELIVERY

*NET PRICES—F. O. B. BALTIMORE*

**TYPE A—$179.00** **TYPE B1—$175.00**

**Complete with tubes and ready to plug in—Prices subject to change without notice**

**NATIONAL RADIO SERVICE CO.**
Reisterstown Rd. & Cold Spring Lane · Baltimore 15, Md.

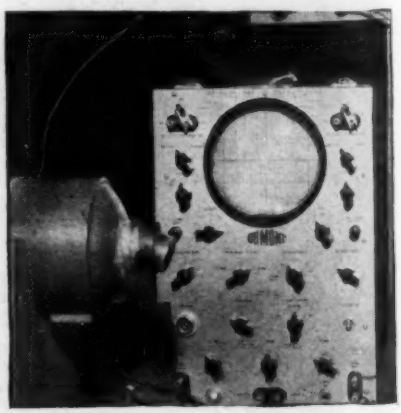

**ELECTRON ART** (continued from p 142)

frequencies. In experimenting on a bolometer, the sensitive element of which was a strip of columbium nitride a centimeter long in a cryostat cooled to about 15 degrees Kelvin (ELECTRONICS, p 226 June 1946), Dr. D. H. Andrews of Johns Hopkins University observed that the bolometer received and detected radio waves when it was operating at the transitional temperature between conductivity and superconductivity. The exact cause of the action is not yet determined.

The observation was made while measuring the inherent noise of the semi-super-conductive bolometer element. A trace on an oscilloscope was ten times the amplitude that would be expected if random motion of electrons at the low temperature were the sole cause of bolometer output. To ascertain the nature of the noise, a loudspeaker was connected to the amplifier. The broadcast from a local station was heard.

Stations at 1,090, 1,200, and 1,400 kc were received and detected by the bolometer. In addition, the performance was explored in the range 0.2 to 30 mc using a standard signal generator. Maxima were observed at 0.9, 2.9, 5, and 16 mc; minima at 2, 4, and 8 mc, the latter one being quite broad. Above 20 mc the action fell below the threshold of measurability.

The columbium nitride bolometer changes its resistance at the rate of about ten ohms per degree Kelvin in the region between 14.34 K



**Radio detecting bolometer is inside the cooling chamber to the left. The output of the bolometer and of a communications receiver were fed through an electronic switch to the oscilloscope and observed to be the same, indicating that the bolometer receives and detects radio waves**

# Shorter and shorter wavelengths

## require better and better dielectrics —

GENERAL CERAMICS
STEATITE*

GENERAL
CERAMICS AND STEATITE CORPORATION
STEATITE INSULATORS

— low loss insulators for low, high, ultra-high and very high frequencies!

If you require low loss insulators with demonstrated ability to function efficiently in any frequency range, and with mechanical characteristics capable of meeting practically any conditions of exposure, shock or vibration, GENERAL CERAMICS steatite products merit first consideration. In many cases, a standard GENERAL CERAMICS insulator will be found available to exactly meet your needs. The specification of these stock items, which are mass-produced to standards that represent the highest attainments in ceramic fabrication, can effect economies of vital importance. Where unusual electrical or mechanical requirements demand an insulator of special design, our engineers will gladly assist in its development. Also, GENERAL CERAMICS production facilities are geared to produce it promptly, accurately and at moderate cost. Your inquiries are invited — write today, no obligation.

* Steatite has a low loss factor — 0.7% at 1000 KC; no moisture absorption; high surface and volume resistivity; high tensile strength. Compressive strength is comparable to cast iron. Practically any size or shape is feasible in Steatite.

General CERAMICS and STEATITE CORP.

MAKERS OF STEATITE, TITANATES, ZIRCON PORCELAIN, ALUMINA, LIGHT-DUTY REFRACTORIES, CHEMICAL STONEWARE

# Silent and chatterless

## ...just like an Adlake Relay!

Silent, positive action is just one of *many* Adlake Relay advantages!

Other important ones are:

- Hermetically sealed contact mechanism—impervious to dust, dirt and moisture.
- Liquid mercury-to-mercury contact —no burning, pitting or sticking.
- Armored against outside vibration or impact—designed for either stationary or moving equipment.

Remember, *whatever* your relay needs may be, there's an *Adlake* Relay to do the job. So write today for free, illustrated folder. No obligation, naturally. Address: The Adams & Westlake Company, 1107 N. Michigan, Elkhart, Ind.

ADLAKE RELAY MODEL NO. 1040

THE Adams & Westlake COMPANY

Established 1857 • ELKHART, INDIANA • New York • Chicago

Manufacturers of Adlake Hermetically Sealed Mercury Relays for Timing, Load and Control Circuits

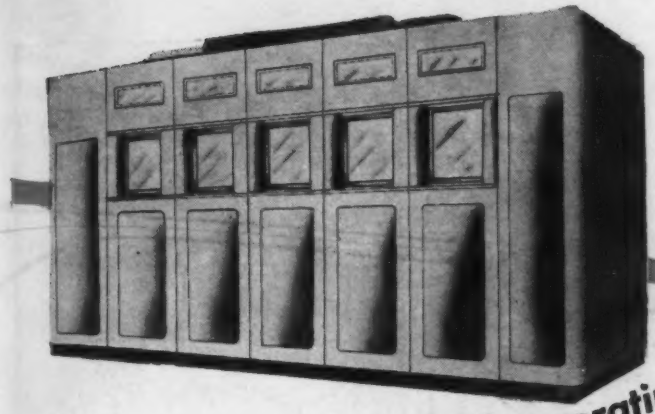



and 14.38 K, this change in resistance being detected in a bridge. In detecting infrared waves the bolometer absorbs the infrared waves, which may either cause the observed change in resistance by changing the temperature of the bolometer or by altering the electronic state within it. As a detector of r-f, the bolometer develops the demodulated signal directly when operated within a region 0.03 K wide at 14.33 K. Less than a milliampere of current through the bolometer stops the detection, either because of electrical polarization or by heating. That detection could be from bimetallic contact is doubtful. That the bolometer should develop a noticeable signal from the r-f is especially remarkable in that it is within a refrigerating chamber that shields it. The rock salt window through which infrared waves are focused on the bolometer was shielded and the output leads were shielded, but the reception of r-f was unimpaired.

Because of the very low resistance of the sensitive element of the bolometer at the low temperature of operation, electrical losses within the bolometer are low. As the energy of the incoming r-f is amplitude modulated, it is understandable that some action similar to that of changing the intensity of incident infrared waves would be produced. However, the remarkable sensitivity of the element to r-f and its production of a demodulated signal indicate a phenomena of which scientists are unfamiliar. The bolometer makes possible the detection for measurement or reception of extremely weak r-f fields.

## Classroom Demonstration of Cathode Follower

HIGH INPUT IMPEDANCE of a cathode follower can be convincingly demonstrated by the circuit shown below. The 60-cps power line voltage is fed in at *A*. The first tube clips the wave, delivering a square-wave to the second tube, which is the cathode follower. The input to the cathode follower is taken off at *B* and observed on an oscilloscope. With switch *S* open, the conductive



*Television Transmitter*

*This unit is manufactured to furnish ranges of 250 watts and upwards, and in power ranges coinciding with power tube development. Individual bays of additional power can be incorporated as needed. Except where additional bays may be required, however, the complete unit can be controlled by a single licensed operator.*

# maximum operating efficiency with minimum personnel!

*Master Control Board*

*This unit includes five video channels, or as many as desired. It also includes dissolving, shading, blanking controls. Simplicity of design enables the master control board to be operated by a single technician. A sync generator and monoscope are integral parts of this unit.*

## SHERRON

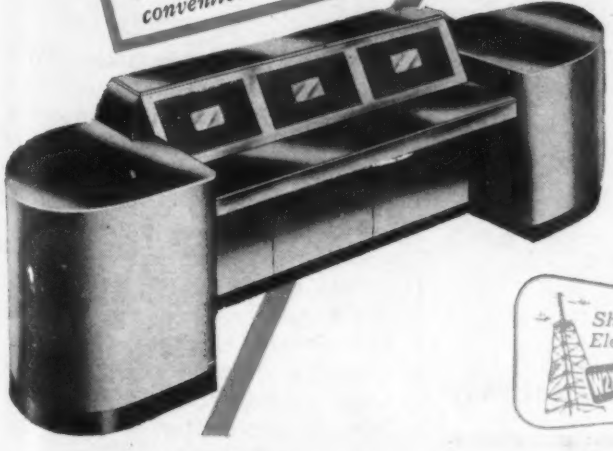
## *Television Studio and Transmitting Equipment!*

Efficient operation by a minimum of personnel! That is the achievement of the improvements both in technical details and design which distinguish Sherron Television Studio and Transmitting Equipment. Unnecessary controls and duplication of executive supervision are eliminated . . . All Sherron equipment is designed, developed and manufactured to the individual manufacturer's specifications.

*Audio Control Console*

*In this Sherron unit all controls are centrally located. Under usual conditions, a single control operator can meter and monitor the aural program with complete ease. Ordinarily, this unit may be adjacent to the studio control console. Thus, the control operator may receive aural instructions from the program director or, if remotely located, by inter-communication.*

*A cordial invitation to visit our factory is extended to all IRE members attending the IRE convention.*



*Studio Control Console*

*This unit is especially designed to afford exclusive control to the program director in charge of the broadcast. The director need not be a technician. His sole concern is the quality of the broadcast. He does not operate the controls but transmits his instructions, by inter-communication, to the master control and studio camera men.*

Sherron Electronics

**SHERRON ELECTRONICS CO.**

Division of Sherron Metallic Corporation

**1201 FLUSHING AVENUE • BROOKLYN 6, NEW YORK**

# Micah is Long-Lived . . .

Micah is long-lived. This perennial juvenile has drunk from the proverbial fountain of youth and eschews vitamin pills and glandular extracts. Gray-bearded old men remember him when *they* were still in swaddling clothes! It's youth! Youth! Youth!

And mica (without the "h") is long-lived, too. Motors and such may wear out, coils and wire may disintegrate, but mica marches on, unchanged by the years. Nothing else lasts as long, nothing else performs as well. There is no substitute for mica. And there is no substitute for *Macallen Mica!*

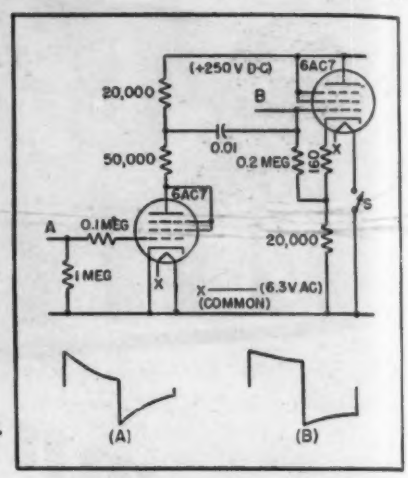
*When You Think of MICA, Think of MACALLEN*

THE MACALLEN COMPANY

16 MACALLEN STREET—BOSTON 27

CHICAGO: 565 W. Washington Blvd. CLEVELAND: 1231 Superior Ave.




**High input resistance of a cathode follower can be demonstrated by closing the switch**

input to the cathode follower so loads the clipper tube that the wave shape at (A) is obtained, but after *S* is closed and the cathode follower becomes operative, the wave shape changes to that at (B) showing the increase in apparent input resistance introduced by the cathode current. (The Input Impedance of a Cathode Follower, F. Duerden, *Electronic Engineering*, p xiv, Nov. 1946).

## Calibrating Laboratory Standards Against WWV

By GARDNER P. WILSON
*Naval Ordnance Test Station*
*Pasadena, California*

FREQUENCY STANDARDS in laboratories can be simply and rapidly calibrated against radio station WWV's short-wave broadcasts by using an oscilloscope as a watch with a second hand revolving 100 times a second. The technique reduces observational errors.

### *Propagation Effects*

At great distances from WWV, signals are received by sky-wave reflections from the ionized layers. Variations in apparent elevation of these layers change the path length of the radio waves. Often these variations in path length are rapid so that the standard carrier or tone arrives at the receiver at a different frequency from the original. This Doppler effect introduces considerable error on short observations made several thousand miles from the transmitter. For long du-

# . . . Impromptu Discussions about Miniature Tubes

"No matter how you look at it, Joe, those TUNG-SOL Miniature Tubes are a far better bet than the old larger types. Better service for the user, more compact equipment for the set builder and less storage space for the dealer are obvious advantages, but that is only the beginning.

"TUNG-SOL Miniatures stand up better under shock and vibration. You see they are more rigid . . . built with smaller, lighter parts. Then there is the glass button base. It not only can't come loose, but it has much better dielectric properties than the old style base.

"Now take high frequency circuits. You know how important they have become. TUNG-SOL Miniatures are doing jobs you couldn't even begin to do with old fashioned tubes. The shorter leads on the Miniature make for low lead inductance and low inter-element capacities.

"Joe, if you want your equipment to be modern you ought to consider using Miniatures. TUNG-SOL engineers will be glad to help you plan the circuits and select the tubes. You can talk to them in confidence."

**TUNG-SOL**
*vibration-tested*
**ELECTRON TUBES**

**TUNG-SOL LAMP WORKS, INC., NEWARK 4, NEW JERSEY**
Sales Offices: Atlanta • Chicago • Dallas • Denver • Detroit • Los Angeles • New York
*Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors*

# Micah is Long-Lived . . .

Micah is long-lived. This perennial juvenile has drunk from the proverbial fountain of youth and eschews vitamin pills and glandular extracts. Gray-bearded old men remember him when *they* were still in swaddling clothes! It's youth! Youth! Youth!

And mica (without the "h") is long-lived, too. Motors and such may wear out, coils and wire may disintegrate, but mica marches on, unchanged by the years. Nothing else lasts as long, nothing else performs as well. There is no substitute for mica. And there is no substitute for *Macallen Mica!*

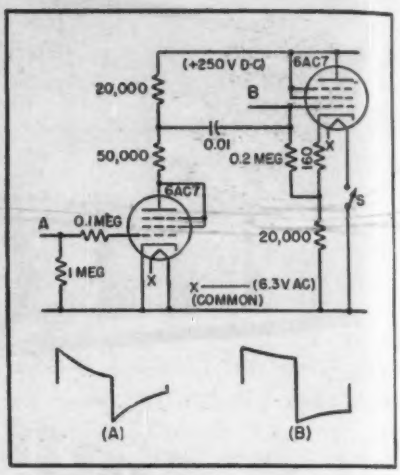
*When You Think of MICA, Think of MACALLEN*

THE MACALLEN COMPANY

16 MACALLEN STREET—BOSTON 27

CHICAGO: 565 W. Washington Blvd. CLEVELAND: 1231 Superior Ave.






**High input resistance of a cathode follower can be demonstruted by closing the switch**

input to the cathode follower so loads the clipper tube that the wave shape at (A) is obtained, but after *S* is closed and the cathode follower becomes operative, the wave shape changes to that at (B) showing the increase in apparent input resistance introduced by the cathode current. (The Input Impedance of a Cathode Follower, F. Duerden, *Electronic Engineering*, p xiv, Nov. 1946).

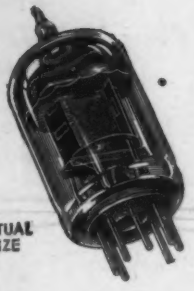
## Calibrating Laboratory Standards Against WWV

By GARDNER P. WILSON
*Naval Ordnance Test Station*
*Pasadena, California*

FREQUENCY STANDARDS in laboratories can be simply and rapidly calibrated against radio station WWV's short-wave broadcasts by using an oscilloscope as a watch with a second hand revolving 100 times a second. The technique reduces observational errors.

### *Propagation Effects*

At great distances from WWV, signals are received by sky-wave reflections from the ionized layers. Variations in apparent elevation of these layers change the path length of the radio waves. Often these variations in path length are rapid so that the standard carrier or tone arrives at the receiver at a different frequency from the original. This Doppler effect introduces considerable error on short observations made several thousand miles from the transmitter. For long du-




# . . . Impromptu Discussions about Miniature Tubes

"No matter how you look at it, Joe, those TUNG-SOL Miniature Tubes are a far better bet than the old larger types. Better service for the user, more compact equipment for the set builder and less storage space for the dealer are obvious advantages, but that is only the beginning.

"TUNG-SOL Miniatures stand up better under shock and vibration. You see they are more rigid . . . built with smaller, lighter parts. Then there is the glass button base. It not only can't come loose, but it has much better dielectric properties than the old style base.

"Now take high frequency circuits. You know how important they have become. TUNG-SOL Miniatures are doing jobs you couldn't even begin to do with old fashioned tubes. The shorter leads on the Miniature make for low lead inductance and low inter-element capacities.

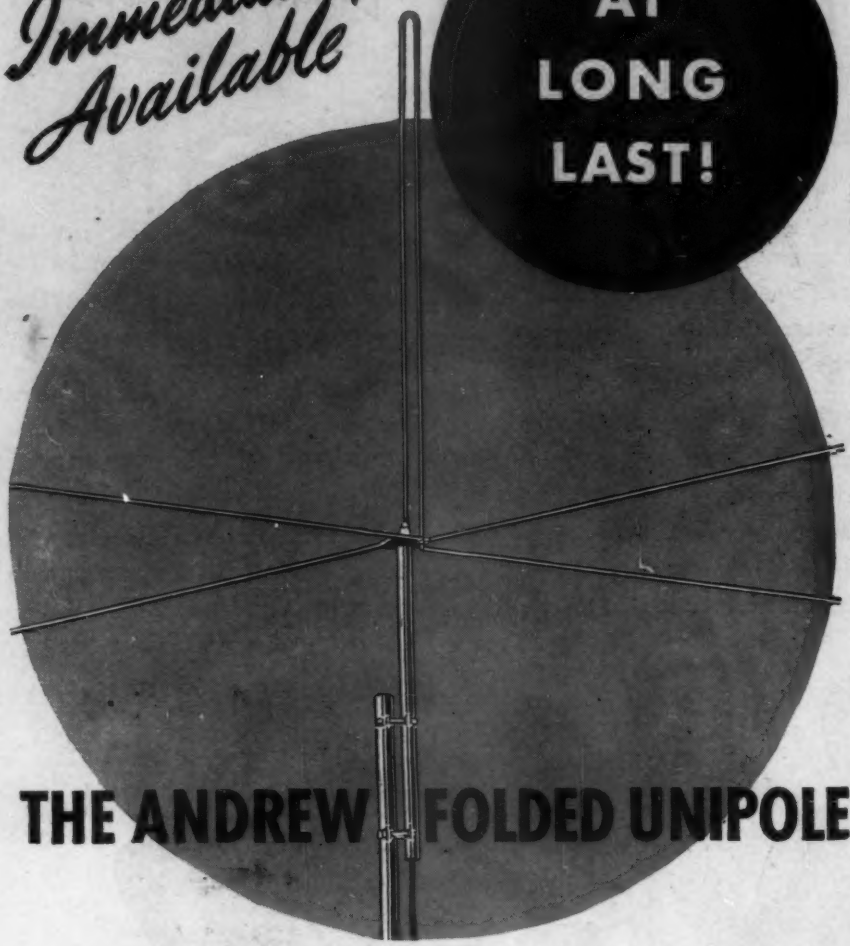
"Joe, if you want your equipment to be modern you ought to consider using Miniatures. TUNG-SOL engineers will be glad to help you plan the circuits and select the tubes. You can talk to them in confidence."

**TUNG-SOL**
*vibration-tested*
**ELECTRON TUBES**

**TUNG-SOL LAMP WORKS, INC., NEWARK 4, NEW JERSEY**
Sales Offices: Atlanta • Chicago • Dallas • Denver • Detroit • Los Angeles • New York
*Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors*

*Immediately Available*

AT LONG LAST!



THE ANDREW FOLDED UNIPOLE

Greeted with a flood of orders when introduced last year, the popular Andrew Folded Unipole Antenna now is flowing off the production line at a rate which permits immediate shipment from stock.

Used for transmitting and receiving in the 30 to 44 MC and 72-76 MC frequency ranges, it easily outperforms other antennas selling at several times its price. Here is the ideal communications antenna for police, fire, forestry, railroad and aviation services.

SEND IN YOUR ORDER NOW

***Here's why this antenna is unusually satisfactory:***

- Perfect impedance matching eliminates tricky adjustment of loading. Users report transmitter loads the same on antenna and dummy, regardless of line length.
- Improved signal strength over ordinary coaxial or other dipole antennas.
- Grounded radiating element provides static drain, improving signal to noise ratio and minimizing lightning hazard.
- Weighs only 20 pounds with clamps. Easy to install.
- Inexpensive. Antenna costs only $60.00, mounting clamps $6.00, transmission line adaptor kit $6.00 (specify size and type of Line).

ANDREW

ANDREW CO.
363 EAST 75th STREET · CHICAGO 19

*For effective solutions to your antenna problems consult Andrew Co., designers, engineers and builders of antenna equipment. Expert factory installation service available.*




ration observations, average received frequency is identical to that transmitted.

Because the standard frequency arrives at the receiver by several different paths, fading occurs, which at times causes the signal to disappear and reappear with large phase shifts. The phase shift is very apparent when using an oscilloscope to view the received wave. These fades and shifts make it extremely difficult to observe sinusoidal waves for enough time to determine average frequency and keep a particular reference crest or hollow of the received signal on oscilloscope screen.

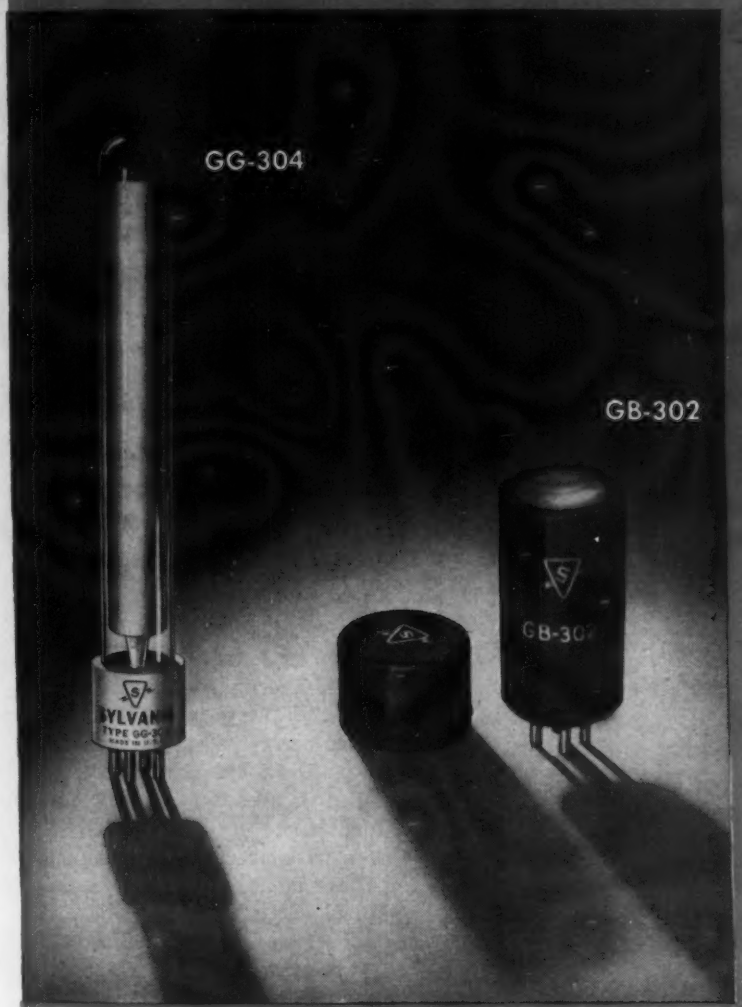
Attempts to use either carrier or modulation of WWV as reference for calibration of laboratory standards in Pasadena, California, approximately 2,500 miles from the source, gave unreliable results because of the above difficulties. Doppler frequency shifts of about one part in 10,000 were observed on all short waves and on the tone modulation frequencies.

*Observational Method*

One possibility of minimizing effects of fading and momentary frequency shift is to divide the ticks transmitted for 0.005 sec every second by WWV to run a synchronous electric clock. This procedure requires extra equipment and necessitates taking observations over a period of many days to obtain suitably high accuracy; it gives no information about short time errors in the laboratory standard, such as crystal oven temperature cycling or line voltage variations.

A more satisfactory method is to feed the 100 cps signal from the laboratory standard, which usually has outputs of 10,000, 1,000 and 100 cps in addition to the generated 100,000 cps, to the vertical plates on an oscilloscope, and to the horizontal plates by way of a 90 deg phase shifting circuit (an 0.05 $\mu$f capacitor in series with a 4,000 ohm resistor) so as to produce a 100 cps circle on the oscilloscope, comparable to a hand of a watch that makes 100 rps. In addition, audio output of a communications receiver tuned to WWV is applied to one set of deflection plates of the oscilloscope. One second tick from WWV then appears as a wave ex-

# NEW SYLVANIA G-M TUBES ...FOR DETECTION AND MEASUREMENT OF RADIOACTIVITY!




For the first time, counter tubes of *stable, uniform characteristics* are now available for practical use in the field of radioactivity.

Formerly, tubes of this type were hand-made — delicate, variable products of the laboratory glass-blower. Through Sylvania research and development, vacuum tube production techniques have now been adapted to their manufacture, with the resulting advantages of stability during tube life, and uniformity from tube to tube.

Use of Sylvania laboratory and manufacturing techniques enables the external quench circuit tubes to be produced in quantity, to bring the customer the advantages of stability and much longer life.

## FEATURES

**LONG LIFE UNIFORMITY**
**DEPENDABILITY STABILITY**
**CONVENIENCE**

## APPLICATIONS OF SYLVANIA GEIGER-MUELLER TUBES

Sylvania Tube GB-302 is a beta-ray counter, utilizing a thin but rugged window of metal foil. It is extremely sensitive to the beta-radiation of the majority of available radioactive isotopes.

The GB-302 will be particularly valuable in tracer techniques, and is also well adapted to medical diagnostic and therapeutical uses.

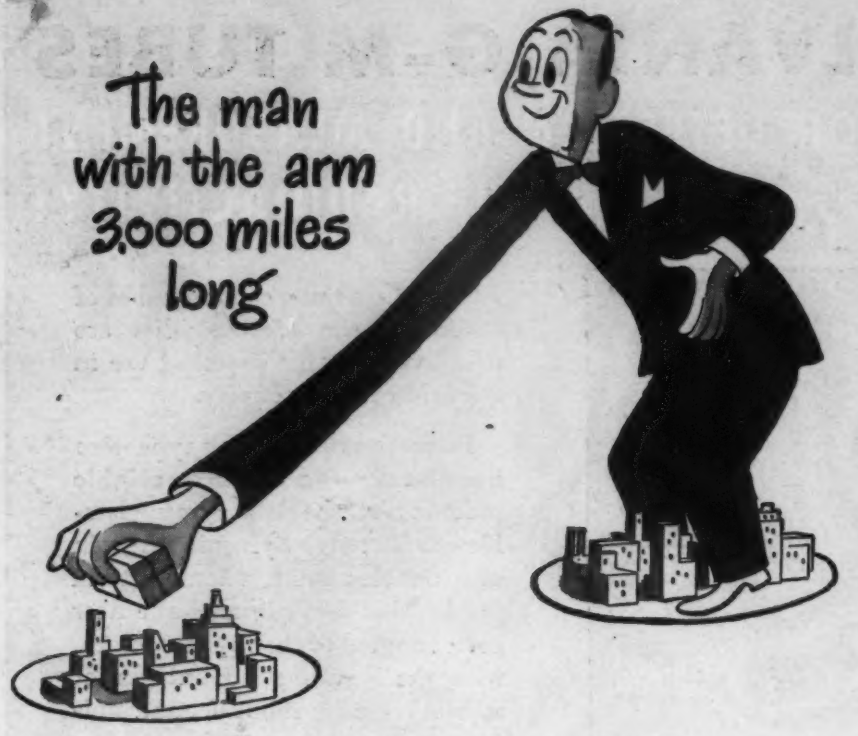
Sylvania Tube GG-304 is the gamma-ray counting companion to the GB-302. It is useful in radiological safety surveys and other applications where gamma radiation must be efficiently measured. In addition, Sylvania Tube GG-304 can be used for cosmic ray studies, especially in coincidence work.

*Write for full details.*

# SYLVANIA ELECTRIC

*Electronics Division . . . 500 Fifth Avenue, New York 18, N. Y.*

MAKERS OF ELECTRONIC DEVICES; RADIO TUBES; CATHODE RAY TUBES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS




**In his business** — just like yours these days — he is always running out of supplies and parts he needs in a hurry. Yet customers have to be satisfied.

Well, he doesn't have a nervous breakdown. He doesn't lose customers. Instead, he gets *what* he needs *when* he needs it by specifying Air Express delivery.

"Air Express," he said, "is like reaching out to any supplier's warehouse *wherever* it is — and picking up just what's wanted. Air Express puts the most distant suppliers *right next door.*"

## Specify Air Express - it's Good Business

- Low rates. • Special pick-up and delivery at no extra cost.
- Direct by air to and from principal U. S. towns and cities.
- Air-rail to 23,000 offairline communities.
- Direct air service to and from scores of foreign countries.

Just phone your local Air Express Division, Railway Express Agency, for fast shipping action . . . Write today for Air Express Rate Schedules containing helpful shipping aids. Address Air Express, 230 Park Avenue, New York 17, N. Y. Or ask for them at any Airline or Railway Express Office. Air Express Division, Railway Express Agency, representing the Airlines of the United States.

AIR EXPRESS

AIR EXPRESS

GETS THERE FIRST

**Rates are low**

To Air Express a 5 lb. package 1349 miles costs only $2.32! Heavier weights similarly inexpensive. Investigate!




tending half way around the circle and repeating itself every 100 revolutions. If the laboratory standard is precisely on frequency, the wave will appear stationary, however any drift will appear multiplied 100 times, simplifying observation of errors. If the beginning of the tick is used as the reference point, and if the reference point drifts 36 deg. in 100 sec., the laboratory standard is in error one part in 100,000. Shorter intervals can be used for observations and good accuracy obtained for checking oven cycling and line voltage variation effects on the laboratory standard.

Accuracy of the one second tick from WWV for any one second is within 0.00001 sec. (one part in 100,000). An observation 100 sec. long will reduce this error to one part in 10,000,000. The longer the observation, the smaller the error becomes in comparison with other fixed errors. Changes in radio path length affect arrival time of ticks in the same manner as they do the carrier. The variation introduces random movement of the tick wave around the 100 cps circle, usually within five degrees of arc. However, the average point can readily be seen. Fading will often cause the tick wave to disappear in part or altogether, but it will reappear and the reference cycle can easily be identified.

It is wise precaution when making these measurements to make a rough check that one second ticks are not appearing every 99 or every 101 revolutions of the oscilloscope trace. A Lissajou pattern using the tone modulation and the local 100 cps will give a quick check. Best receiver tuning for viewing the tick is with the receiver exactly centered on the carrier frequency, half way between tone modulation sidebands. This tuning can easily be verified by oscilloscopic observation as the receiver is tuned.

### Impedance Measurements

ELECTRICAL IMPEDANCES, whether they are resistances, inductances, or capacitances, can be quickly measured by varying a known impedance to produce a squarewave trace on a cathode-ray oscilloscope. The circuit for making such meas-

# CONCENTRICITY...

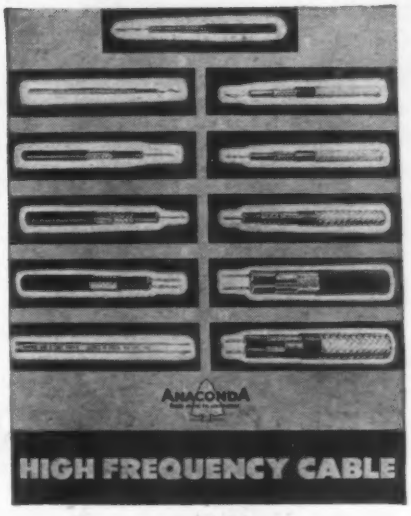
## For Uniform Transmission Characteristics in High Frequency Lines

IN COAXIAL CABLES, more than in any other types, accurate relationship between the component parts is essential.

Concentricity and uniformity of conductors and dielectric join in Anaconda Coaxials to effectively fulfill the objectives of electrical designers.

Each type is specifically designed to serve best in the intended application. All electrical characteristics are held within close limits to uniform standards assuring accurate surge impedances.

In addition to manufacturing standard types of coaxial cables, Anaconda offers research and engineering facilities to meet needs for specialized types.

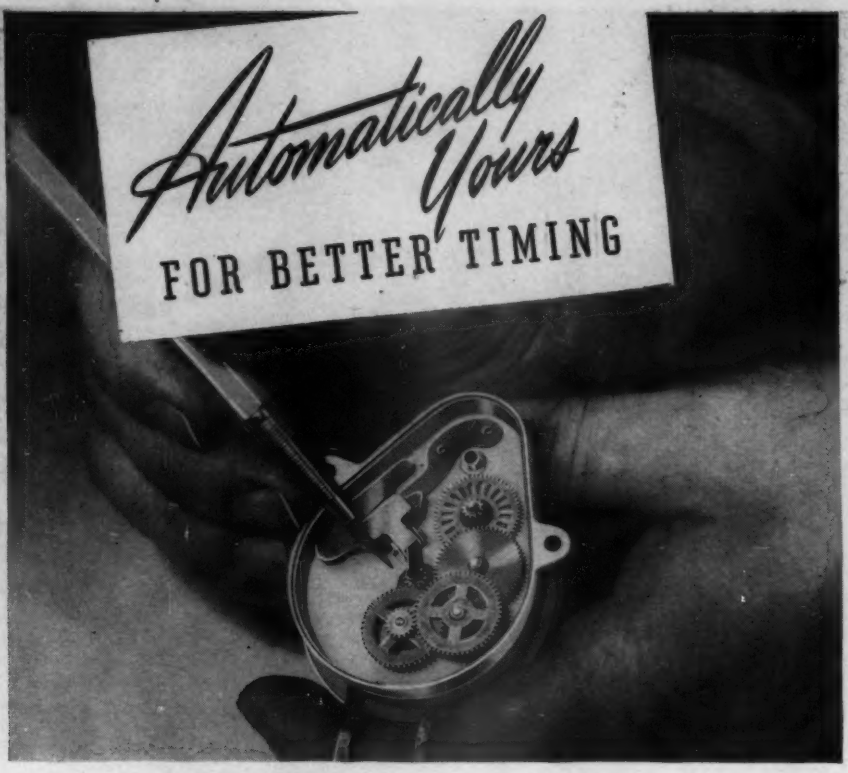



ANACONDA
from mine to consumer

## ANACONDA WIRE & CABLE COMPANY

GENERAL OFFICES: 25 Broadway, New York City 4
*Subsidiary of Anaconda Copper Mining Company*
CHICAGO OFFICE: 20 North Wacker Drive 6 • Sales Offices in Principal Cities

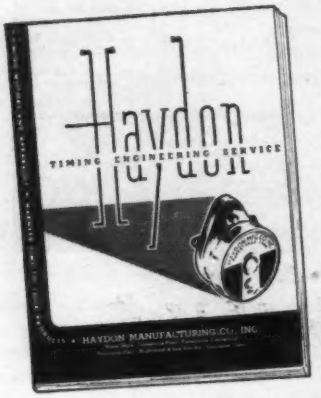
*Write for these useful, new folders containing characteristics of Anaconda high-frequency coaxial cable and television lead-in lines. Address: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.*




# HAYDON Automatic Reset

For applications such as time delay relays, where automatic re-setting is required, HAYDON engineers have built into the #1600 series gear unit a magnetically operated counterbalanced gear shift. This automatically engages and disengages the gear train when the motor field is energized and de-energized. The drive shaft is then reset back to starting position by an external spring. It gives uniform engaging and disengaging action, irrespective of the mounting position of the motor.

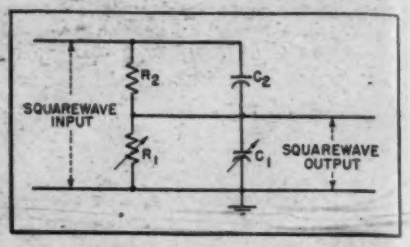
**• This construction is available in speeds from 15 RPM down to one revolution in 10 minutes.**




*Write for the new HAYDON catalog for detailed description of this and other HAYDON timers.*

TIMING ENGINEERING SERVICE
Haydon
MANUFACTURING COMPANY
* INCORPORATED *
Forestville, Connecticut
SUBSIDIARY OF GENERAL TIME INSTRUMENTS CORPORATION






**Impedances can be measured in a balanced attenuator by adjusting for the condition at which a complex input waveshape is reproduced in the output**

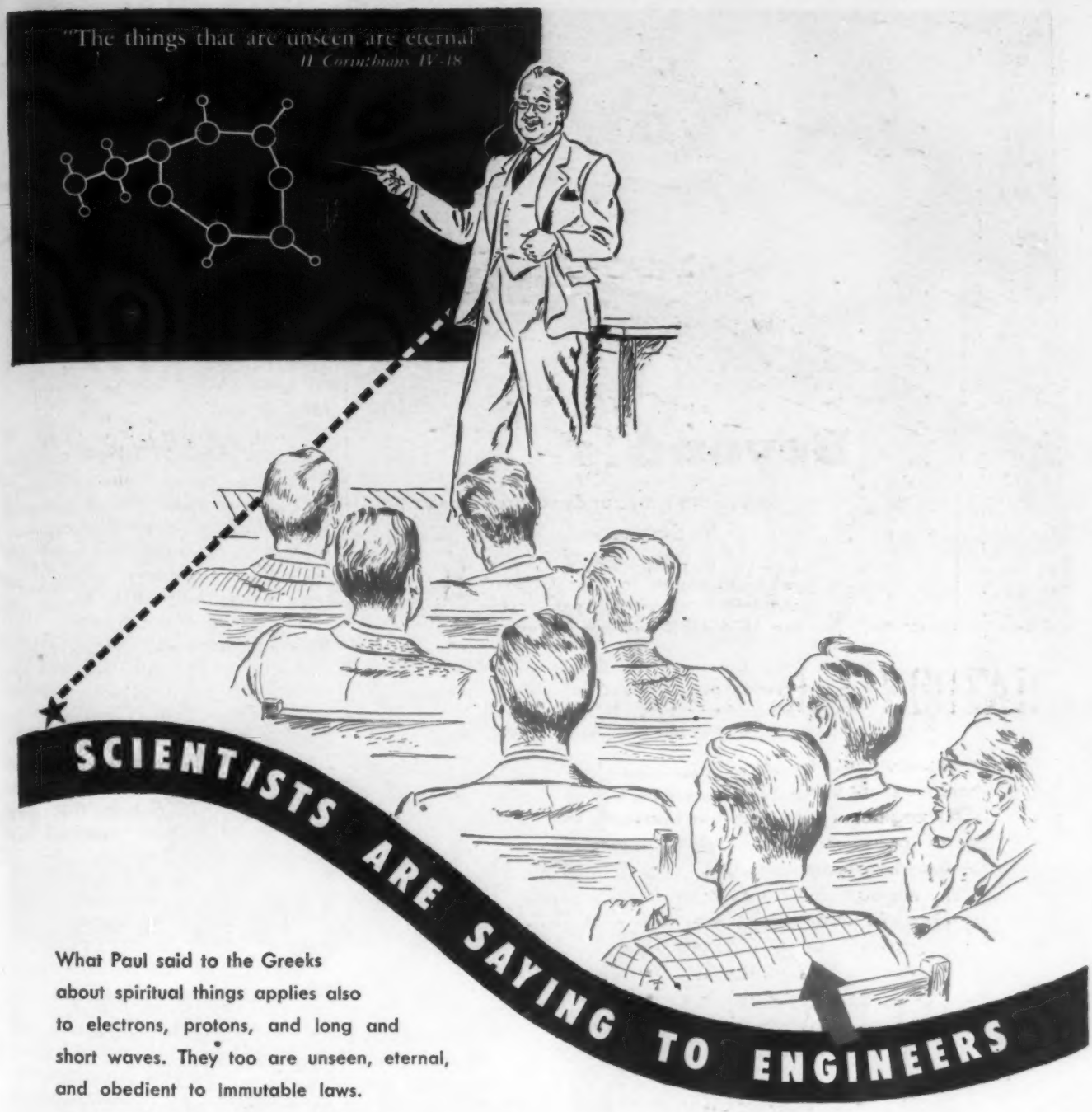
urements is shown in the accompanying drawing, where the two capacitors could be replaced by two inductors if desired. It should be noted that if inductors are used, their inherent resistances can be used for $R_1$ and $R_2$, obviating the need for connecting separate resistors.

The circuit operates as a balanced attenuator. A squarewave of any convenient frequency is applied to the input. The output is connected to the vertical deflection channel of an oscilloscope the sawtooth sweep of which is synchronized to the squarewave. Impedances of the measuring network are adjusted until a squarewave is displayed on the oscilloscope, under which condition $R_1C_1 = R_2C_2$ or $R_1L_2 = R_2L_1$, where these values are effective, including stray impedances. Any of the impedances can be varied, preferably one that is grounded. If the reactance across the lower portion of the network is too large, the output squarewave will be peaked at its rising edge; if that reactance is too small, the output will be rounded at the rising edge. (U. S. Patent 2,409,419 granted 15 October 1946 to Peter S. Christaldi, assignor to Allen B. DuMont Lab., Inc.)

## Radio Reflection from the Moon

By ZOLTAN BAY
*Technical University*
*Budapest, Hungary*

EXPERIMENTS to observe reflection of 120-mc radio waves from the moon, started in the summer of 1944 but interrupted until August 1945, succeeded on February 5, 1946. Theoretical considerations indicated that a long transmitted pulse and a narrow received bandwidth prior to detection were re-




What Paul said to the Greeks about spiritual things applies also to electrons, protons, and long and short waves. They too are unseen, eternal, and obedient to immutable laws.

They are forever going somewhere. They can heal or kill. They can give light and sound and heat and power if we control them.

Insulating materials are one of our most important tools for this job. For more than thirty years Formica has been one of the best tools for many such purposes, and definitely the very best for some.

You are the judge, but good as its reputation is, you will not try to judge Formica for your purpose without examining the properties and specifications of the various grades, and considering their strength, durability, workability and cost. Why not ask us to send this information on a grade we can recommend for the purpose you mention in your letter. It might call for one of the grades that are too new for you to know what it could mean for you.

FORMICA

**THE FORMICA INSULATION COMPANY 4661 SPRING GROVE AVENUE, CINCINNATI 32, OHIO**

# Beyond...

..."the great undiscovered ocean of truth"...

We can venture into the UNKNOWN in any branch of research only as fast as we can MEASURE each new conquest.

New Hathaway instruments are being developed and standard designs are being constantly improved to keep abreast of the expanding demands of modern research.

Whatever your requirements may be in special instruments for measurement or control let Hathaway instrument engineers help you.

Hathaway Type S8-B 12-element oscillograph—one of a complete line of recording oscillographs

You can rest assured that you will find in any Hathaway instrument the *most advanced design*, and the *most exacting craftsmanship*.

WRITE FOR TECHNICAL BULLETIN SP-165

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO




quired for high signal-to-noise ratio. However, it was necessary to use a broadband receiver because of anticipated drift of transmitter frequency.

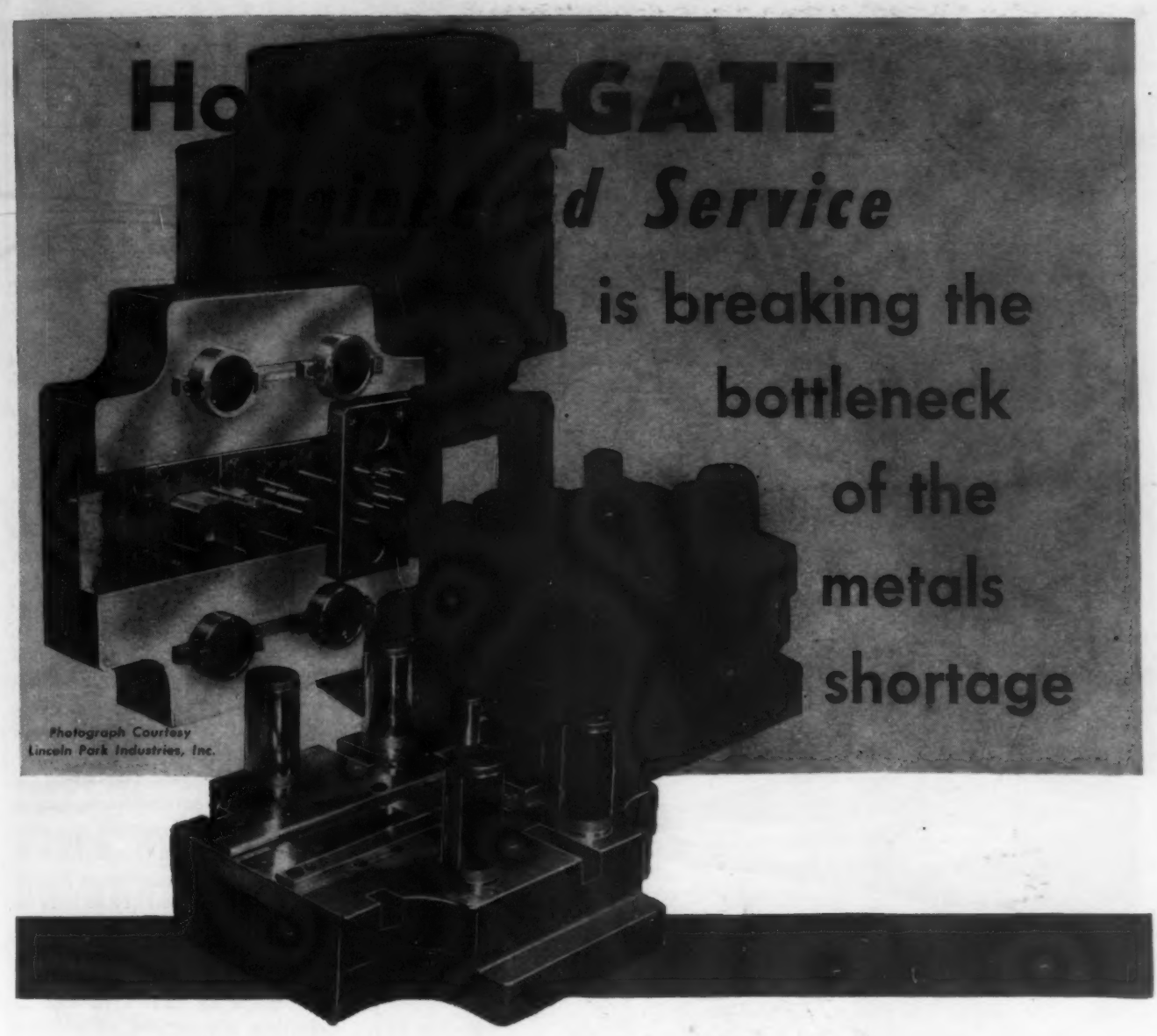
To obtain a signal despite the noise, a method of cumulation was used. As conventionally used in radar, cumulation is provided by long-persistence cathode-ray tubes; the signal luminescence is integrated but the noise luminescence is averaged. Thus the improvement in signal-to-noise is a function of the time over which integration is carried.

Calculations indicated that it would be necessary to perform the integration for about an hour. Capacitance circuits were considered unsatisfactory, so an electrochemical method of cumulation was used. A bank of hydrogen coulometers were sequentially switched to the receiver output and timed so that the same one would always be connected when the reflection was received. In operation, four percent more hydrogen was separated in the coulometer receiving the signal than in the others, with a probable error of one percent. The signal-to-noise ratio obtained in this way corresponds to the theoretically computed ratio. The equipment is being used to measure solar radiation at 2.6 meters, which is being correlated with solar activity.

## Microwave Spectroscope

USING WAVELENGTHS between 1.2 and 1.6 cm generated by a klystron oscillator, complex hydrocarbon molecules can be nondestructively identified. The equipment consists of the elements shown in Fig. 1. The oscillator and the trace of the cathode-ray tube are swept in synchronism by the sweep generator. Microwave energy passes through the 15-ft. waveguide, containing the gas to be analysed, to the crystal detector.

The gas selectively absorbs frequencies that are characteristic of its molecules. Thus the output developed by the crystal and displayed on the crt as a function of frequency is indicative of the gas under test. To obtain high selectivity, the gas is at low pressure, about 0.1 mm of mercury. The




**MANY MANUFACTURERS** have asked us whether it is possible to make an assembly or part in another metal *temporarily,* and still use the fabricating and stamping tools, when the time comes, for the preferred metal.

It's not only frequently *possible* . . . Colgate is *doing it.* By designing double purpose dies so that they may be used, during this interim period with a second-choice material, and later converted, Colgate is breaking the bottleneck of the metals shortage.

Dies engineered to serve a double purpose is just one example of Colgate *Engineered Service* in sheet metal fabricating and stamping of aluminum, magnesium, stainless steel and many other light metals.

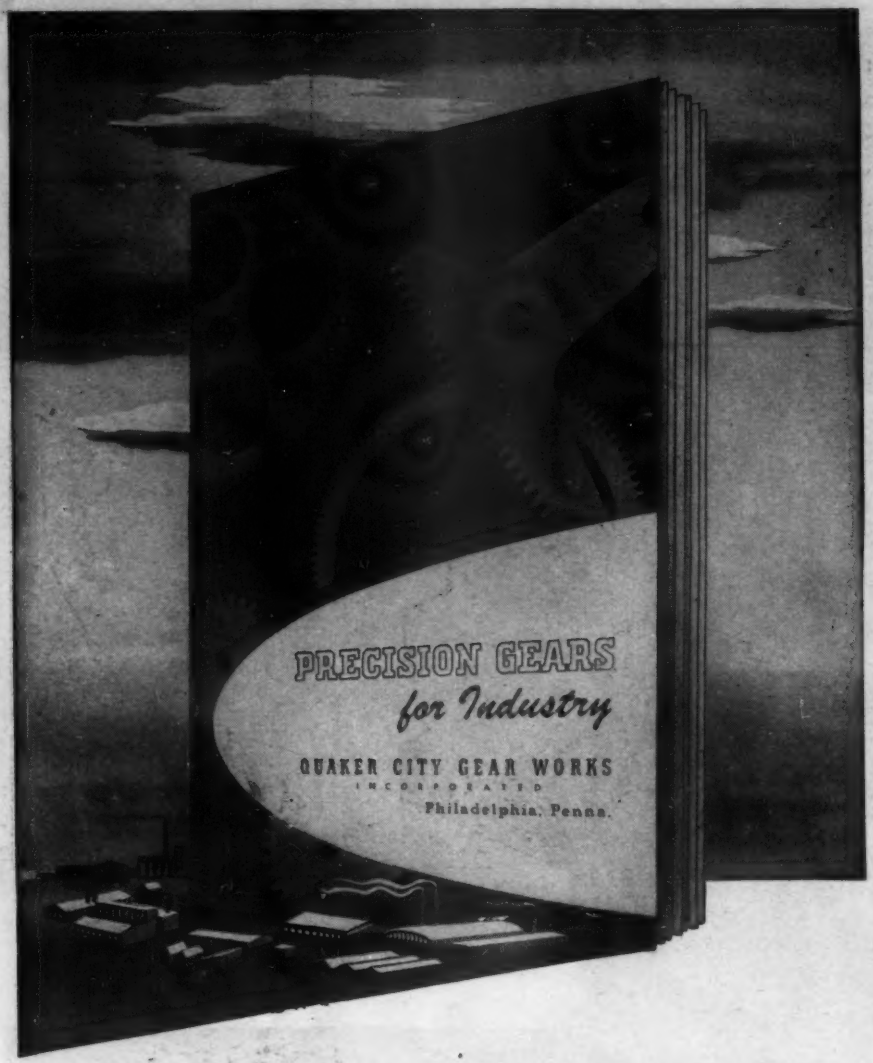
If your product is ordinarily made of steel (let's say), perhaps some other material could be used. Then, when steel becomes *available,* in many cases the tools can be converted, at reasonable cost, through Colgate's *Engineered Service.* Write for more information.

**STAMPING • FORMING • DRAWING • WELDING • FINISHING • ASSEMBLING**

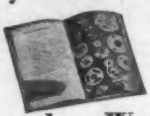
**COLGATE** *Manufacturing Corporation*

AMITYVILLE, LONG ISLAND, NEW YORK

LIGHT METALS PRODUCTS




# Yours for the asking

**A new informative booklet on gears. It has illustrated sections** **on practically every known form of gearing, together with**  **many reference tables and formulas. Write for your copy today on your company stationery.**

**Quaker City Gear Works**
INCORPORATED

**1910 N. Front Street, Philadelphia 22, Pa.**



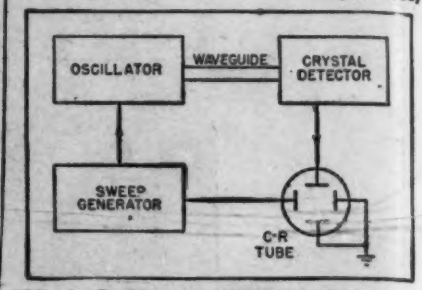



**FIG. 1—Basic components of microwave spectrograph**

collision frequency of the gas molecules should be less than the operating frequency.

Ammonia, observed to absorb microwaves about ten years ago (*Phys Rev*, p 234 45 1934), has been found to have 30 different absorption lines in the region of operation of the microwave spectrograph developed by Dr. William E. Good, physicist at Westinghouse Research Laboratory. Water vapor, acetone, cyanogen bromide, and carbonyl sulfide have also been identified by the technique. Other molecules, especially organic gases having dipole moments, can be identified by the spectroscope.

In making measurements, gas is admitted to the waveguide gas cell, which is sealed with plastic tape at its ends. The absorption is shown as a series of vertical deflections on the crt. These lines are compared to those obtained from samples of known gases. Photographic records can be made as shown in Fig. 2.

Selective absorption of electromagnetic radiation at wavelengths between a millimeter and a centi-

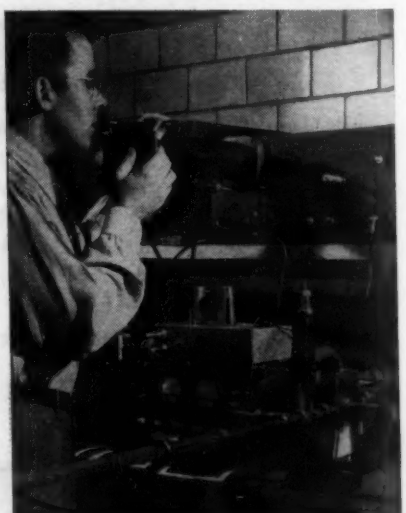


**FIG. 2—Photographing microwave absorption bands as displayed on cathode-ray tube**

# Don't buy an electronic heater *blindly*

## INVESTIGATE AND INSIST ON PROOF BY TRIAL — WITH AUTOMATIC OR HAND-OPERATED APPARATUS

Have you soldering, brazing, surface-hardening, annealing or other heat-treating operations? Or do you use heat to treat non-metallic substances such as plastics, plywood, rubber, etc.?

It is quite possible that you can use electronic heating apparatus for these operations, profitably replacing older and slower heating methods. The savings and increased efficiency are decidedly worthwhile. The speed-up in production is as great as 700% in some instances. Work that formerly took minutes or hours now requires only SECONDS.

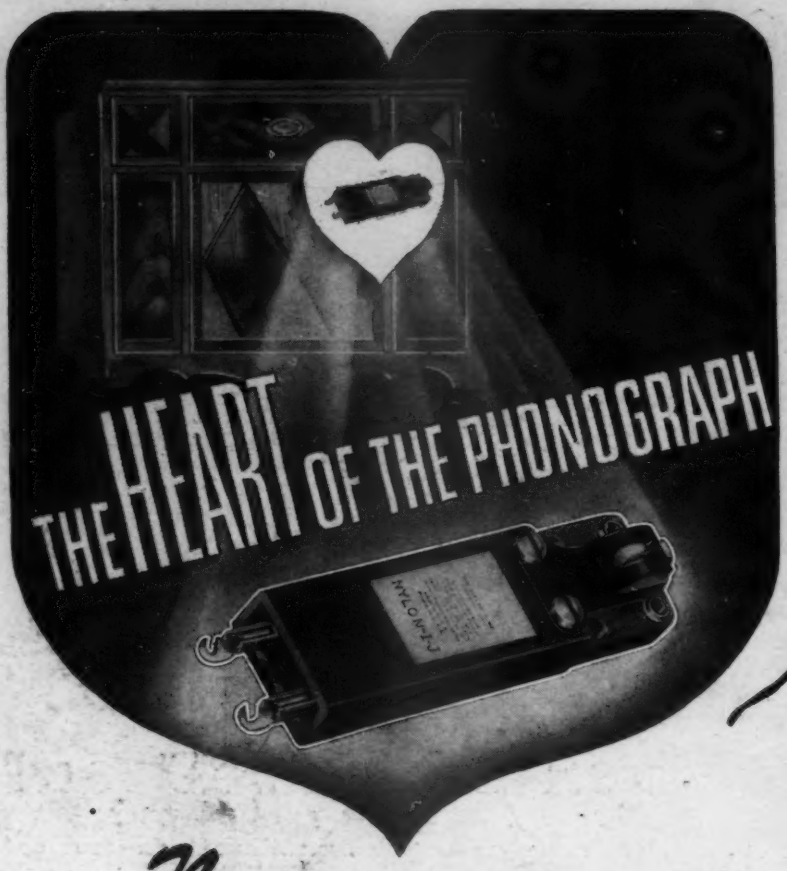
Investigate the possibilities of high frequency heating for your production. But be sure to get plenty of sound experienced advice before you buy. Don't just buy a "machine." Let our engineers prove to you by actual demonstration under your own conditions, how Scientific Electric equipment fits your exact needs. Remember, there is no such thing as an all-purpose electronic heater. Each individual operation and each factory production set-up requires a specific type of installation, with the proper combination of frequency and power output. Consult us without obligation. We will engineer the right installation to your particular requirement. Buy nothing till we've PROVED IT BY TRIAL for you.

**NOW—IMMEDIATE DELIVERY**

**Scientific Electric Electronic Heaters are made in the following range of power:** 1—3—5—7½—10—12½—15—18—25—40—60—80—100—250KW. — and range of frequency up to 30 Megacycles depending on power required.

# Scientific Electric

DIVISION OF
Corrugated Quenched Gap Co., 107 Monroe St., Garfield, N. J.




No other part of a modern phonograph is so important as the small crystal cartridge mounted in the pickup or reproducer arm. This cartridge is the pulsating heart of the instrument and upon the degree of efficiency of its operation depends the quality of reproduction.

It is not surprising, therefore, that many radio-phonograph manufacturers and engineers are expressing intense interest in Astatic's new Nylon I-J Phonograph Pickup Cartridge. Designed with Nylon Chuck and MATCHED, sapphire-tipped, knee-action Nylon Needle, this cartridge improves performance with respect to needle life and frequency response, suppresses mechanical resonance, improves tracking at low needle pressure and reduces record wear. Other important advantages and details concerning Astatic's new Nylon Cartridge are given in special literature now available.

THE Astatic CORPORATION
ASTATIC
CONNEAUT, OHIO
IN CANADA: CANADIAN ASTATIC LTD., TORONTO, ONTARIO

Astatic Crystal Devices Manufactured under Brush Development Co. patents.

*Visit your Radio Parts Jobber or Write for New Catalog.*



meter by water vapor in the atmosphere has been observed with radar (*Trans A. I. E. E.*, p 209 April 1946). Recently it was shown that the same technique could also be used to measure pressure and rate of diffusion of gases (*Jour Appl Phys*, p 495 June 1946). Atoms can rotate about the intramolecular bonds, as is done in dielectric absorption. However, if the resonant frequency of the bond rotation, determined by the force of the bond and the masses of the atoms, is used in exciting the molecule, the absorption of energy will be very large. Measurements of frequency and absorption at these resonant points indicate the internal construction of molecules. The technique might be extended to use of ultrasonic vibrations as well as to electromagnetic vibrations to further separate phenomena associated with purely mechanical causes from those from electrical causes (*Jour Aco Soc Am*, p 285 Jan 1946). As each gas molecule has its characteristic resonant frequencies and energies of absorption, a study of the absorptions of microwaves serves to identify the gases present in the sample.

## Modulation of Concentrated-Arc Lamp

CONCENTRATED-ARC LAMPS[1] have two electrodes sealed into an argon-filled glass bulb. The radiation emitter is a thin film of molten zirconium, a cloud of ionized zirconium vapor, and the excited argon gas. The diameter of the 2-watt lamp is 0.003 in., affording virtually a point source[2, 3] of light. Radiation from the molten, incandescent zirconium has a continuous spectral distribution extending from 2,500 A in the ultra-violet, through the visible spectrum, reaching a maximum near 10,000 A, and continuing into the infrared to 5 microns where it is cut off by the glass of the bulb. In addition, the mixed vapor gives all the usual zirconium and argon lines distributed chiefly between 0.7 and 0.9 micron. Radiation from the molten zirconium shows a rapid decrease in modulation percentage with increase in frequency and spectral

# A Guide to the "GUIDE"

## HAVE YOU RECEIVED YOUR FREE COPY?

A booklet of information on the ELECTRONICS Buyers' Guide is now available. It contains facts about the value and use of the "Guide"... gives reasons why the "Guide" is a "must" medium in electronic and allied fields.

**MANUFACTURERS:** This booklet shows . . . the unique value of the "Guide" in selling both name and product . . . the type of information your advertising should supply . . . why the men who design-in, specify, and buy in electronic fields use the "Guide" as their year 'round reference book.

**ADVERTISING AGENCIES:** This booklet provides basic facts on how the "Guide" influences all the buying factors in electronic fields. It includes the results of a survey among ELECTRONICS' subscribers revealing their appraisal of the "Guide" as a source of buying information, their evaluation of the advertising content, and their needs in catalog type presentations. Be sure to send now for this free booklet of information on the facts, value, use, mechanical requirements, rates, etc., of the . . .

**Get the FACTS, VALUE, USE of the ONLY COMPLETE CATALOG AND DIRECTORY OF ELECTRONIC EQUIPMENT COMPONENTS and ALLIED PRODUCTS**

*Published* **JUNE 15 1947**

# electronics

## BUYERS' GUIDE ISSUE

ABC • A Bonus Issue To All Subscribers • ABP

A McGRAW-HILL PUBLICATION · McGRAW-HILL BUILDING NEW YORK 18, N. Y.

# The Ghost In Rev. 4

● And it was such a beautiful tracing when it first left the board – but look at the prints now, after that last revision . . . a nice big "ghost" firmly astride the front elevation. Moral . . . don't use inferior tracing cloth.

If this tracing had been on Arkwright, Rev. 4 would have produced prints just as sharp as the day a tracer first initialed it . . . because Arkwright's special mechanical process *prevents* "ghosts". This oil, wax and soap-free method of manufacture builds the translucency *all the way* through. Arkwright cloths *can't* discolor, grow brittle with age.

See for yourself how much better Arkwright is. Send for free working samples. Arkwright is sold by leading drawing material dealers everywhere. Arkwright Finishing Company, Providence, R. I.

**All Arkwright Tracing Cloths have these 6 important advantages**

1 *Erasures re-ink without "feathering"*
2 *Prints are always sharp and clean*
3 *Tracings never discolor or become brittle*
4 *No surface oils, soaps or waxes to dry out*
5 *No pinholes or thick threads*
6 *Mechanical processing creates permanent transparency*

Arkwright
TRACING CLOTHS
AMERICA'S STANDARD FOR OVER 25 YEARS



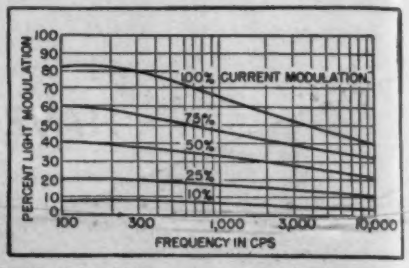



**FIG. 1—Modulation response of the 2-watt lamp when used with an antimony phototube**

wavelength; radiation from the gas and vapor can be almost completely modulated at all audio frequencies[4, 5]. The resultant modulation in a special application is shown in Fig. 1.

Frequency characteristics of a system using the concentrated-arc lamp and a phototube depend on the spectral response of the phototube.* The blue-sensitive antimony tube is preferable to the red-sensitive caesium type. Although the modulated radiation increases with increasing wattage of the lamp, the percent modulation obtainable decreases. Percentage modulation can be increased by increasing the gas pressure. The dynamic relation between radiation and modulating current not being linear, there is some modulation distortion, chiefly second harmonic.

When operated at 50 percent modulation, all lamps have an inductive impedance, the larger lamps having less impedance. As shown in Fig. 2, there is a frequency at which the lamp has minimum impedance; this frequency decreases as the lamp size increases. The lamps have a negative resistance component (EI curve) at low frequencies. The light always lags the current (IL curve), the lag increasing with frequency. The impedance of the 2-watt lamp is sufficiently high to permit connecting the lamp directly into the plate circuit of a

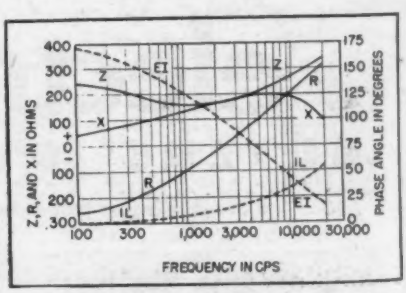



**FIG. 2—Modulation impedance characteristics of the 2-watt lamp**

# Where there is Horsepower...

# *There is Wire*

Coal . . . Water . . . Oil . . . these are our sources of power. Our early use of each of them was crude and localized and wasteful—before the time of electrical wire.

Now, wire harnesses horsepower. Wire traps it at its birth—even bringing about its generation. Wire packages power and brings it into our homes. Wire transforms power into a thousand different characters.

The use of horsepower is a many-sided science, now that wire is here. Each specialized application has its specialized wire counterpart. The development of these wires is in itself a scientific undertaking . . . a challenge . . . an achievement . . . a source of pride for the wiremakers among whom a pioneering leader is Belden Manufacturing Company.

**Belden** WIREMAKER FOR INDUSTRY

# SCA rectifiers of tomorrow

## IN DESIGNS OF TODAY!

SCA Selenium Rectifiers are ENGINEERED FOR ENGINEERS. Improved performance at lower costs through ENGINEERED adaptability. Selenium Corporation of America meets exacting specifications of modern electronic developments. Manufacturers of a broad line of Selenium Power and Instrument Rectifiers, Self generating Photo-Electric Cells and allied scientific products.

Selenium Rectifiers are rapidly becoming standard in industry for all rectifier applications. Selenium Corporation of America's engineering experience can be called upon for the development and production of special rectifiers for any application.

**CHECK THESE OUTSTANDING FEATURES:**

- Permanent characteristics
- Adaptability to all types of circuits and loads
- Unlimited life—no moving parts
- Immunity to atmospheric changes
- High efficiency per unit weight
- From 1 volt to 50,000 volts rms.
- From 10 micro-amperes to 10,000 amperes
- Economical—simple to install—no maintenance cost
- Hermetically sealed units available

SCA

**SELENIUM CORPORATION OF AMERICA**

Affiliate of VICKERS Incorporated

1719 WEST PICO BOULEVARD • LOS ANGELES 15, CALIFORNIA 46-E

OHIO "Application Proved" MOTORS

PREVENT Product FAILURES

Check These Four Advantages of OHIO MOTORS

✓1 FREEDOM FROM VIBRATION: All Ohio AC Motors are of the squirrel cage type, which are inherently in balance. Rotor and shaft assemblies are dynamically balanced.

✓2 FREEDOM FROM HEAT: Better-than-adequate ventilation provides longer life for bearings and windings.

✓3 FREEDOM FROM DIRT: All internal parts are fully protected against falling chips, dirt and dripping liquids.

✓4 FREEDOM FROM LUBRICATION WORRIES: Large oil reservoirs, packed with wool yarn, provide generous lubrication. Ball bearings are of the self-sealing type... do not require lubricating for years.

THE OHIO ELECTRIC MFG. CO.
CHESTER BLAND, Pres.
5908 Maurice Ave. • Cleveland 4, Ohio



6L6. Also, the direct current necessary to maintain the arc (55 ma) is sufficiently low as to be supplied by the modulator tube. A high voltage must be momentarily applied to the lamp to strike the arc.

(1) Concentrated-Arc Lamp, W. D. Buckingham and C. R. Deibert, *Journal of the Optical Society of America*, p 245, May 1946.

(2) A New Point-Source Lamp for the Laboratory, Harry L. Smith, *American Journal of Physics*, p 313, September-October 1946.

(3) Characteristics and Applications of Concentrated-Arc Lamps, W. D. Buckingham and C. R. Deibert, *Photographic Society of America Journal*, p 610, November 1946. (See also: New Concentrated-Arc Lamp, G. S. Oslin, *International Photographer*, p 12, July 1946.)

(4) The Concentrated Arc-Lamp as a Source of Modulated Radiation, W. D. Buckingham and C. R. Deibert; paper presented at the 1946 SMPE winter convention, to be published in *Journal of the Society of Motion Picture Engineers*. (See also: Characteristics and Applications of Concentrated-Arc Lamps by the same authors, *Journal of the Society of Motion Picture Engineers*, p 376, November 1946.)

(5) Modulation Characteristics of Concentrated-Arc Lamps, W. D. Buckingham and C. R. Deibert, The Western Union Telegraph Co., Electronics Research Laboratories, Water Mill, L. I., N. Y.

## Electronics in the Food Industry

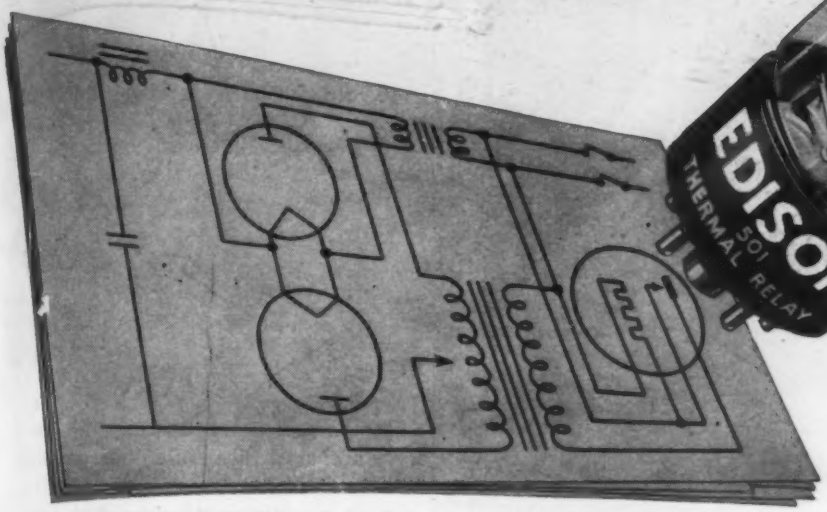
RESEARCH is finding the manner in which dielectric heating can be used in dehydrating foods and for thawing frozen foods. With insufficient data on dielectric constants of various foods, the investigation proceeds slowly, but possibilities can be foreseen.

### *Dehydrating*

Determination of moisture content is essential in dehydration processing. Several commercial types of dielectric moisture meters are available. Among the factors that affect measurements of moisture content by the dielectric-constant method are temperature, particle size, and density of compaction of sample. For reproducible moisture measurements these conditions must be duplicated from sample to sample.

Experiments on potatoes revealed that well-compressed blocks could be produced only if the potatoes contained 15 percent moisture. To further dehydrate the compressed blocks to seven-percent moisture, required for proper preservation of the blocks, dielectric heating was found faster than vacuum-oven drying. The initial drying rate was much faster because of the internal heating produced by the dielectric technique. However, once the block

# Why the EDISON thermal relay protects electronic tubes



## Delays plate voltage application until cathode is properly heated

PROTECTION OF CATHODES in electronic tubes, such as thyratrons and gas filled rectifiers, depends on allowing cathodes to reach operating temperature rather than delaying application of plate voltage for a fixed time. A thermal relay, since its operation also depends on attaining a predetermined temperature, is eminently suitable for cathode protection.

The Edison Thermal Relay is widely used for this purpose because (**a**) its delay characteristics vary with line voltage as does cathode heating; (**b**) it is suitable for continuous operation; (**c**) it offers sustained accuracy; (**d**) it has a wide range of delay periods; (**e**) it is silent and positive in operation; (**f**) it is as independent of ambient temperatures as the cathode it is protecting; (**g**) it is relatively inexpensive; (**h**) it is small and lightweight. The slow cooling rate of the Edison Thermal Relay prevents loss of equipment operating time due to momentary power interruptions.

The combination of the foregoing features indicates that this is the best device available for cathode protection.

Edison engineers will help solve your cathode protection problems if you will write and give them the data. Just address Instrument Division, Thomas A. Edison, Incorporated, 24 Lakeside Avenue, West Orange, New Jersey.

## Here's What It Is

**1. ELECTRICAL HEATER** — (5 watts nominal up to 150 volts AC/DC) deflects bi-metal to actuate contacts.

**2. CONTACTS**—rated at 6 amperes at 250 volts AC or DC for delays less than 1 minute. For delays longer than 1 minute, rating can be increased to 500 volts AC or DC if reduced to 3 amperes. S.P.S.T. normally open or closed.

**3. MOVING CONTACT ARM**—carried by bi-metal, is a preloaded spring, which applies full contact pressure immediately. Action absolutely noiseless and positive in operation.

**4. FACTORY-ADJUSTED SCREW**—sets contact spacing for desired operating time—5 seconds to 8 minutes.

**5. COMPENSATING BI-METAL**—maintains pre-set contact spacing and relay timing, regardless of ambient temperature variations.

**6. "E" SPRINGS**—braced between sturdy ceramic support and glass tube, make assembly shock proof.

**DIMENSIONS,** 1¼" diameter, 3¼" height (seated).

**WEIGHT,** 0.08 lb.

**HERMETICALLY SEALED** in glass envelope, relay is tamper-proof, fully protected from dust, dirt, corrosion, or contact with outside air, with operation independent of altitude.

**ARC-QUENCHING ATMOSPHERE** guarantees absolute minimum of contact fouling, pitting, or transfer; permits equal AC or DC ratings.

**STANDARD RADIO TUBE BASE** 4-pin or octal.

AN **EDISON** CONTROL

THOMAS A. EDISON, Incorporated
Instrument Division, 24 Lakeside Avenue
West Orange, New Jersey

GENTLEMEN:

Please send me your Bulletin No. 3007X on the Edison Thermal Relay.

NAME _____

COMPANY _____

ADDRESS _____

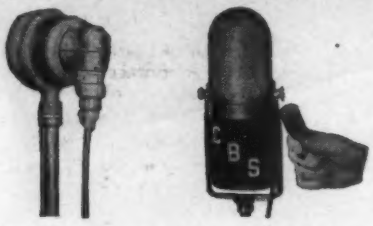
CITY _____ ZONE NO. _____

STATE _____

# *Dependable* MICROPHONE PLUGS *by* CANNON ELECTRIC

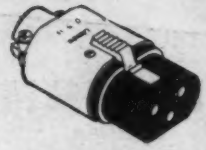
*Judy Canova, radio star, broadcasting over NBC in Hollywood, with Hal Gerard and Joe Kearns. RCA microphone is equipped with Types "O" or "P". ALL RADIO NETWORKS USE CANNON MICROPHONE PLUGS.*

*Left:* Type "O3-42" Receptacle and "O3-11" Plug on Western Electric table type mike used by Columbia Broadcasting Co. *Center and Right:* Other large network mikes use type "O" for cable extension. The latchlock device prevents accidental disconnection resulting from jerks or strain on cord.



*Left:* Microphone with "P-42" Receptacle and P-CG-11 Plug used for platform public address. (Photo courtesy Reiss P. A. Systems, Detroit). *Right:* Mike used by CBS-Hollywood, with P-CG-12 plug shown in hand. As in the case of the above Type "O", two mating "P" plugs can be used conveniently for cable extension where receptacle is not an integral part of the microphone itself.

The New lightweight Type "XL" is standard equipment on the equally new RCA "Announce" Microphone which has a unique construction in the stem, allowing the plug to swing into the stem with a cover. Relief spring on XL-3-11 plug protects cord from sharp bends. Adapters are available to users of microphones such as the Turner (second to right) for those desiring to convert to Cannon "XL" Plugs.



TYPE "O"

Two plugs and six receptacle styles available in this series. One oval insert arrangement with three 30-amp. contacts for No. 10 B&S stranded wire.

TYPE "P"

Five plugs and nine standard receptacle styles available in six insert arrangements; two to six 30-amp. contacts, one eight 15-amps. for No. 14 B&S stranded wire.

TYPE "XL"

Two small plugs and four receptacles with zinc shells carry three 15-amp. contacts for No. 14 B&S stranded wire. Equipped with compression gland and relief spring.

TYPE "XL"

Two steel shell XL plugs for rough, heavy-duty usage. Same insert arrangement as above. Integral clamp construction and leading XL features.

Write Dept. B-120 for C-46A Condensed Catalog, describing all above connectors and list prices. Available from jobbers everywhere.

CANNON ELECTRIC DEVELOPMENT COMPANY

3209 Humboldt Street, Los Angeles 31, California

Canada & British Empire — Cannon Electric Co., Ltd., Toronto, Ontario • World Export Agents (excepting British Empire) Frazar & Hansen, 301 Clay St., San Francisco 11, Calif.




had been thoroughly heated, the rate at which the water vapor could diffuse out of the block determined the speed with which drying could proceed.

Potatoes dried by the faster dielectric heating process did not have as good quality as the slower oven-dried ones. Apparently a low temperature is desirable at the beginning of the drying cycle. Modification of the dielectric heating process to meet this condition would counteract its advantage of speed. Where the material to be dried is not subject to damage by heat, dielectric heating would be preferred.

*Thawing*

Precooked, frozen foods in either small domestic or large processing packages thaw slowly and unevenly if, as is usually done, they are removed from refrigeration and stood at room temperature. Portions of the package to thaw first spoil before the entire package thaws.

Experiments conducted on one-pound packages left in their cardboard wrappers indicated that the rate of temperature rise was practically uniform during the electronic thawing process; in conventional thawing, temperature rises exponentially. The time for thawing by dielectric heating was one-thirtieth that of conventional methods, being minutes instead of hours; thus there is little opportunity for spoilage. (Research in Agricultural Products, by T. L. Swenson, *The Scientific Monthly*, 1946 June 477.)

## Edison Effect

EMISSION OF ELECTRONS from a hot metal, the Edison effect, was studied in the modified lamp shown herewith. This electron emission is now used in the communication and broadcasting industry, in the motion picture industry, and for measurement and control in almost every phase of modern technology from aviation to mining. Thomas A. Edison, born a century ago this February 11th, pioneered in generation of electrical power, incandescent and fluorescent lamps, phonographs, motion picture projectors, and microphones. Not only does mankind benefit from such natural

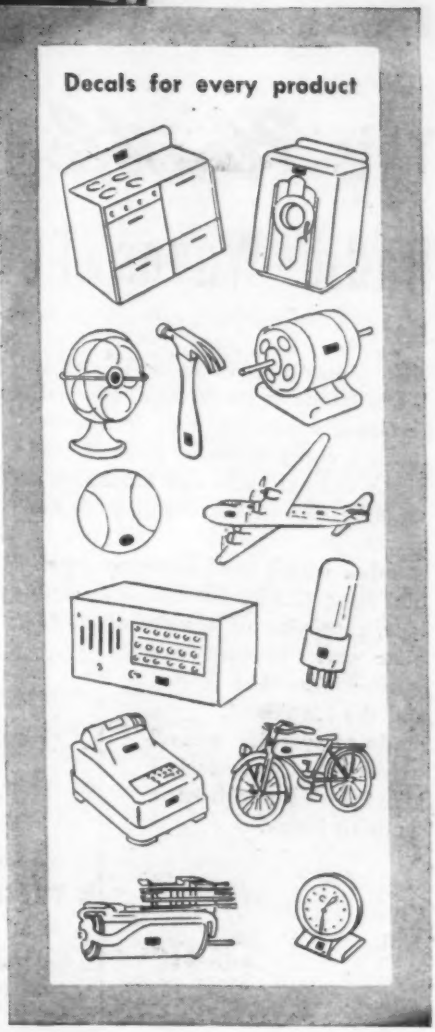
# Colorful, Durable Nameplates that SELL as they IDENTIFY with MEYERCORD DECALS

***NO RIVETS • NO SCREWS***
***Simple adhesion methods assure durable, colorful product identification***

**Conditions under which this "Divine" buffer operates demonstrate Meyercord quality.**

Double-duty, low-cost Meyercord Decal nameplates *advertise* as they *identify*. They offer full color for quick brand recognition! Divine Brothers Co., Utica, N.Y., has used them for years as trademarks of colorful distinction on quality buffing wheels. They resist vibration, fumes, moisture, abrasion, acids, wear and constant use.

Advertise *your* brand-name for the life of *your* products with tough, flexible Meyercord Decals! They can be applied at production line speeds. No screws, rivets... no sharp edges. Washable, durable! Smooth, lasting adhesion on any commercial surface, curved or flat... even on rubber or crinkle finish. Trademarks, operating or lubrication guides, patent data, etc., can be produced in any size, colors, designs. Learn how Meyercord Decals add more "sell" to nameplates! Write today for free Meyercord Decal Selector... it shows where and how to use Decals. Address Dept. 9-2




*Founder-Member Lithographic Technical Foundation*

**The MEYERCORD Co.**
*World's Largest Decal Manufacturer*
5323 W. LAKE ST. ---------- CHICAGO 44, ILL.

# DON'T RISK THE *WRONG* FLUX

Good soldering jobs depend on the right flux—and Kester has the right flux for you. You can count on Kester for a flux that will properly clean, prevent oxidation, make way for a tight bond that will resist shock, vibration, twisting, bending, and the contraction and expansion of temperature extremes.

Growing out of nearly half a century of practical experience, Kester's hundreds of flux formulas have been time-tested in laboratory and industry, to establish exact specifications for every flux need. Among them is the ideal flux formula for your particular soldering job.

Consult Kester engineers at any time for practical, experienced help with flux problems. They'll gladly suggest the right flux to protect your product. A letter today will bring expert Kester assistance—without obligation.

**KESTER SOLDER COMPANY**

**4204 Wrightwood Avenue, Chicago 39, Illinois**

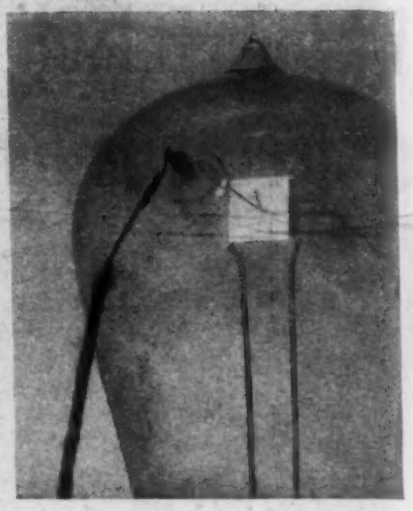
*Eastern Plant:* Newark, N. J. *Canadian Plant:* Brantford, Ontario

**KESTER**

*Solder Fluxes*

STANDARD FOR INDUSTRY





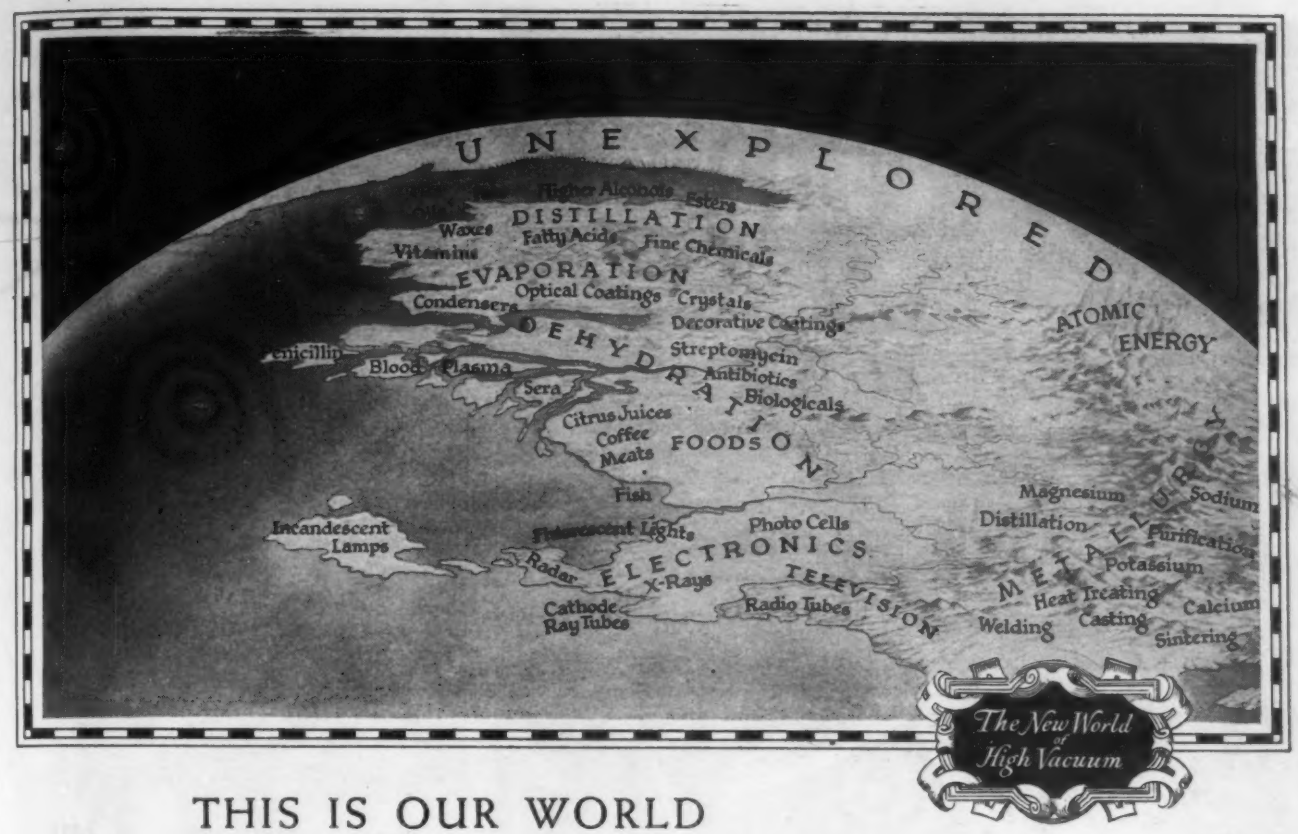
**Electron emission from a hot cathode was first studied in this simple diode**

resources as fertile soil and sunshine, but also from the inquisitiveness and creativeness of individuals such as Edison. The effect of Edison on our lives indicates the importance of fostering those mental and emotional attributes in individuals that make possible socially beneficial basic and applied research.

## Variable Electronic Capacitor

USING THE SPACE CHARGE of a tube, an inertialess electronic capacitor is obtained. Two planar cathodes mutually parallel are mounted on opposite sides of a control grid. As the potential between the grid and the two cathodes is varied, the electron clouds bordering the cathodes move closer to or further from the control grid, thus varying the capacitance between themselves and the control grid. The two variable capacitances appear in series across the two cathodes.

Variation of capacitance is linear with control grid potential over a limited range. At excessively negative potentials, mutual repulsion of the cloud electrons and the fact that the clouds cannot move further from the grid than the faces of the cathodes prevent further capacitance reduction. At excessive positive potentials, the control grid draws current, preventing further increase in capacitance. A high series resistor in the control circuit increases the linear range (U. S. Patent 2,407,424).




# THIS IS OUR WORLD

*The definition of "High" Vacuum is arbitrary. We choose to consider that the term applies to pressures less than 1 mm. Hg. absolute. The use of this pressure range for industrial processing is a recent development. The organized body of empirical information, built from performance records, which characterizes the conventional branches of engineering, is generally not available to the engineer who undertakes a project in High Vacuum.*

The calculation of efficient pipe and manifold sizes, of pumping requirements and capacities, of relative outgassing of construction material, is not easily done with the published data. The effect of very small leaks at very low pressure and the degree of tightness which may be expected with suitably designed and properly built equipment is not generally appreciated. The virtues and the failings of different types of vacuum gauges and the location of these gauges for true control of processing conditions is a small field in itself.

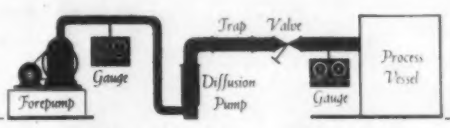
Measurements made during our early experience in building large systems conflicted with existing information on rates of flow at low pressures. An engineer spent twelve months running tests on pipe and tubing from ⅜" diameter to 8" diameter in various lengths up to 35', including elbows, bellows connectors and valves. The results of this work are the basis of our present piping and manifold design.

We have found it necessary to develop special pieces of basic equipment to fill specific needs in the industrial field. Our Thermocouple Gauge was evolved to meet a condition of severe vibration met in the preparation of magnesium. The Alphatron Vacuum Gauge removes the guesswork connected with pressure measurement in the presence of water vapor, a serious problem in High Vacuum Dehydration. We have built diffusion pumps with unusual characteristics to overcome problems in other fields.

Installations of our Vacuum Diffusion Process are now handling 1,000,000 CFM of water vapor at 100 microns Hg. pressure. In one plant another process is pumping in two separate operations 275 lbs./hour of water vapor at 100-200 microns Hg., and 6,500 lbs./hour of water vapor at 8 mm. Hg.

The design and construction of High Vacuum systems of all sizes and for all purposes is our business. We have accumulated a substantial body of practical information on which to base design. Our engineers are familiar with the problems of industrial High Vacuum installations. Our production departments have mastered the requisite fabrication techniques. This is our world.

*If you are considering the use of High Vacuum, we can relieve your engineers of this portion of responsibility. Your inquiry will receive prompt attention and will place you under no obligation.*



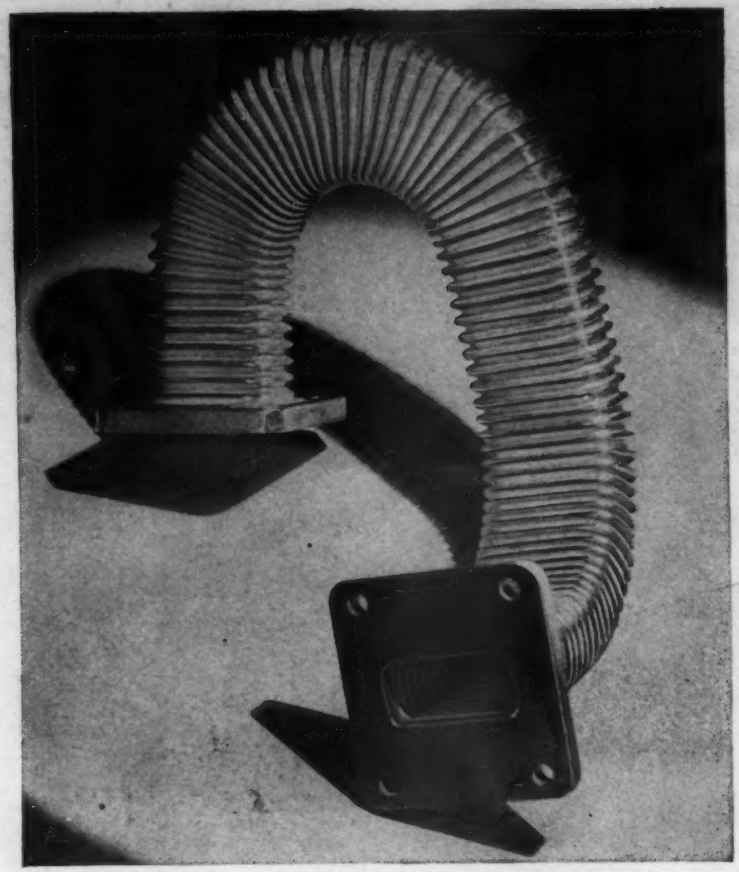

VACUUM ENGINEERING DIVISION, National Research Corporation, Boston 15, Massachusetts.

*We engineer Plant installations and manufacture High Vacuum Gauges, Valves, Seals, Diffusion Pumps, Stills, Furnaces, Coating Equipment and Dehydration Equipment.*

HIGH VACUUM FOR INDUSTRY

# NATIONAL RESEARCH CORPORATION

Vacuum ENGINEERING DIVISION



# This *Flexible* Tubing makes Radio Waves TURN CORNERS...

THIS AMERICAN Seamless Flexible Wave Guide is made from thin-wall rectangular metallic tube... can be extended, compressed or bent in two planes to small radii and withstands a large number of flexures of moderate amplitude.

Other widely used American Flexible Wave Guides are the "Vertebra" type, consisting of a series of choke-plate wafers inserted in a synthetic rubber jacket, and the "Moldlock" type, made of spirally wound strip with fully interlocked joints, with (or without) a synthetic jacket.

These high precision units mate electrically and mechanically with the standard sizes of rigid guide for operation at wave lengths from 20 to less than 3 Cm.

We will be glad to assist in selecting the wave guide best suited to the specific requirements of your installation. Write for our "Electronics Data Book."

46361

ANACONDA

*American*

METAL HOSE

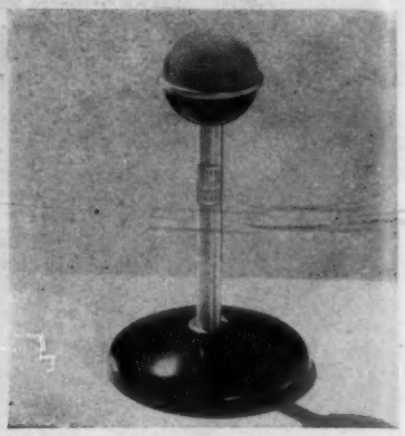
THE AMERICAN BRASS COMPANY

*American Metal Hose Branch*

General Offices: Waterbury 88, Conn.

*Subsidiary of Anaconda Copper Mining Company*

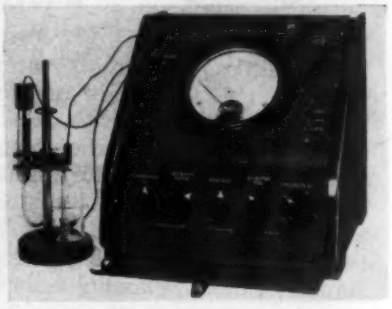

 (continued from p 148)



factured for home-recording, public-address, and amateur radio use. It provides flat response from 40 to 6,000 cycles with output level 50 db below 1 volt dyne per square centimeter open circuit. The microphone is supplied with cable, plug, and removable base.

## Direct Reading pH Meter (21)

MUIRHEAD AND CO., Ltd., Elmers End, Beckenham, Kent, England. Bulletin B-569-B describes the type D-303-B direct reading meter that has an accuracy of 0.05 pH. The equipment may be used alternatively as a high-impedance millivoltmeter. Operating controls are conveniently located on a sloping panel with the meter. Setting-up



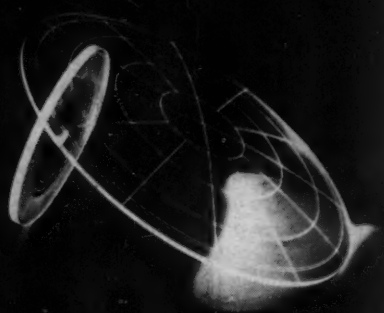
controls are arranged to be covered by a flap after initial adjustments have been made to avoid accidental disturbance.

## Improved Recording Turntable (22)

PRESTO RECORDING CORP., 242 West 55th St., New York 19, N. Y. The model 14-B recording turntable represents an improvement over the model 14-A. The skeleton illustration shows the degree of isolation of

# It's ACCURATE if it's AMPREDIZED

Accuracy of graduation combines with excellent legibility to assure easy, accurate reading when dials, scales, and screens are engraved by the automatic, precision process designated "Ampredizing".



*Large Circles*
Perfect circles, up to 20 inches in diameter, can be engraved as continuous or interrupted lines.

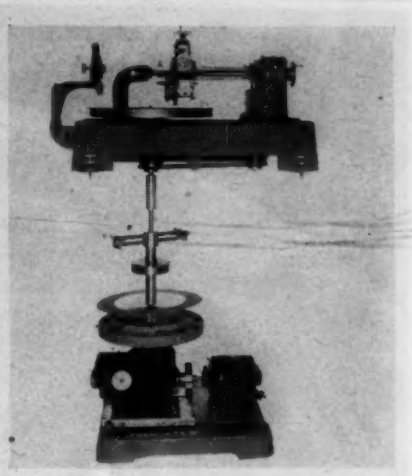
*Anti-parallax Scales*
Scales and screens can be accurately matched on both faces of material up to one-half inch thick.

*Radial and Linear Scales*
A variety of radial scales can be provided as a single dial, with even the closest graduations accurate to 2 minutes in 360 degrees. Straight, linear scales, up to 15 feet long, can be engraved with equal accuracy.

Economical, automatic production makes "Ampredized" scales available at cost generally below that of conventional pantograph engraving. Write for particulars.

American PRECISION DIAL Co.
93 MASSACHUSETTS AVENUE BOSTON 16, MASS

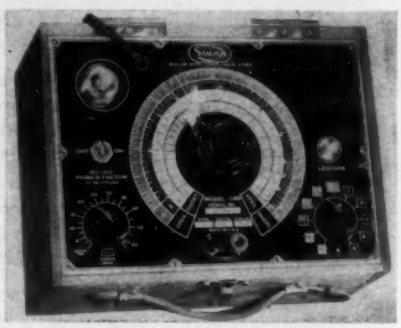


the motor-drive mechanism and the turntable cutting-head platform. Speeds of either 33⅓ or 78 rpm are available. Six different cutting pitches, either inside-out or outside-in can be quickly chosen. The cutting head responds to frequencies between 50 and 8,000 cycles.

### Capacitor Analyzer (23)

SOLAR MANUFACTURING CORP., 285 Madison Ave., New York 17, N. Y. The model CBB capacitor analyzer is direct reading between 10 micro-



microfarads and 800 microfarads. A magic-eye tube is used to indicate balance in the Wien bridge, while a simplified neon lamp test circuit is used for insulation resistance. The instrument may also be used as a line frequency resistance bridge covering a range of 50 ohms to 2 megohms. A complete description is given in catalog IN-2.

### Millisecond Relay (24)

STEVENS-ARNOLD CO., 22 Elkins St., South Boston, Mass. A new relay housed in a metal-tube container and suitable principally for use on

## A CHANGER WITH NEW APPEAL FOR MANUFACTURERS, DEALERS, MUSIC LOVERS

Announcing the new Seeburg Model "M" . . . a record changer to add appeal to even the most glamorous radio-phonograph combinations.

Outstanding among the many fine features of the "M" is its exclusive three-post construction which brings these important record playing advantages:

1. INTERMIX playing of 10 and 12-inch recordings.
2. INCREASED RECORD LOAD. The "M" has a capacity of fourteen 10-inch records, twelve 12-inch records or twelve 10-inch and 12-inch records intermixed.
3. LONGER RECORD LIFE. Multiple post construction assures gentle handling, minimum spindle hole wear.

But more than this the Model "M" possesses all the engineering refinements that have made Seeburg changers the favorites of manufacturers, sellers and buyers alike.

FEATURES OF THE NEW SEEBURG MODEL "M"

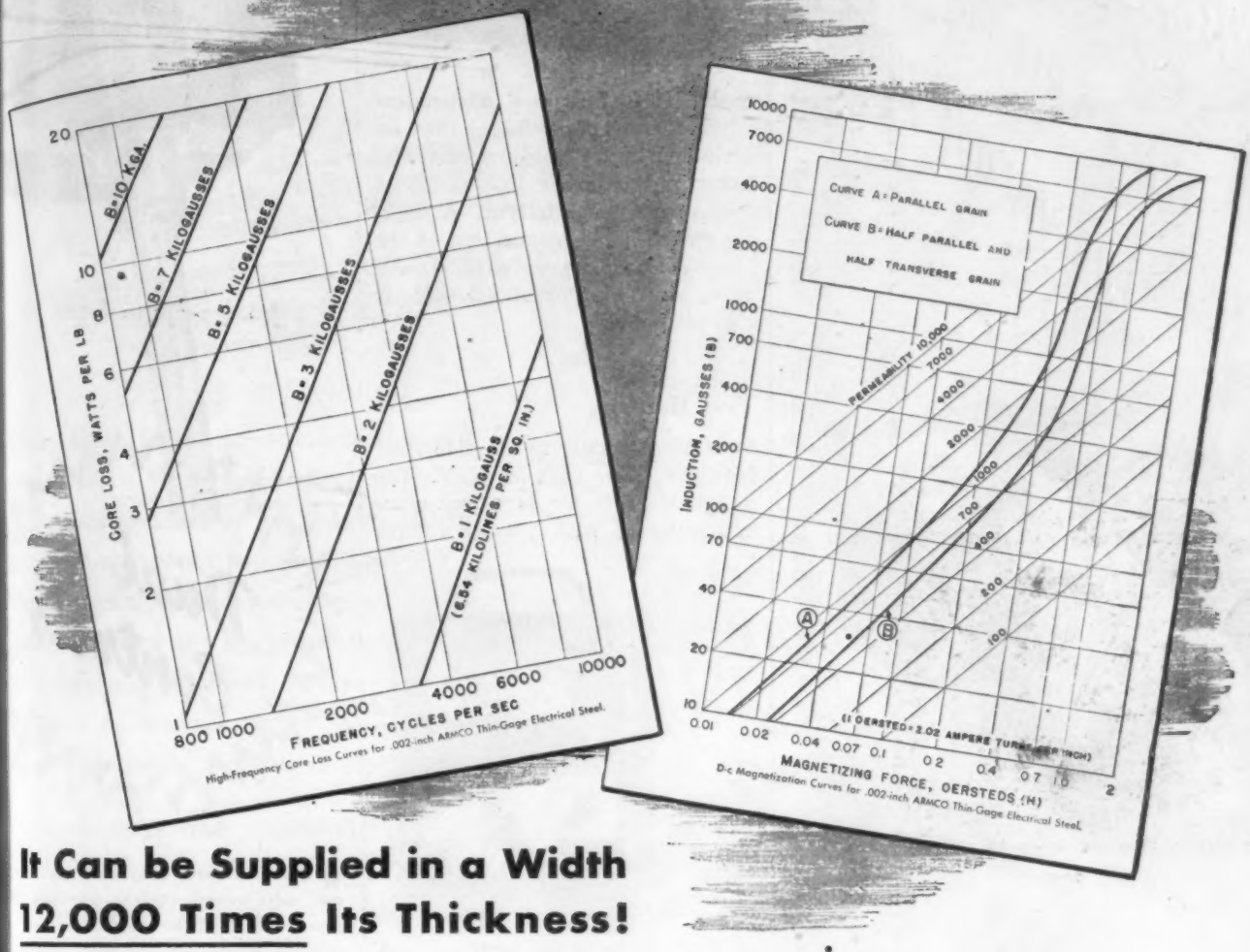
- *THREE-POST CONSTRUCTION that lengthens the life of precious discs, increases record load.*
- *INTERMIX PLAYING of both 10 and 12-inch recordings.*
- *SIMPLE MECHANISM that gives long, trouble-free operation.*
- *SWIFT, QUIET OPERATION that means minimum time between changes—assures pleasurable listening.*
- *CONSTANT SPEED MOTOR that brings turntable up to speed quickly—holds it there.*

Seeburg

RECORD CHANGERS ★ MUSIC SYSTEMS

J. P. SEEBURG CORPORATION
1500 N. DAYTON ST. • CHICAGO, 22

# Can you use *tissue thin* electrical steel?


CORE LOSS, WATTS PER LB
FREQUENCY, CYCLES PER SEC
B=10 KGA.
B=7 KILOGAUSSES
B=5 KILOGAUSSES
B=3 KILOGAUSSES
B=2 KILOGAUSSES
B=1 KILOGAUSS
(6.54 KILOLINES PER SQ. IN.)
High-Frequency Core Loss Curves for .002-inch ARMCO Thin-Gage Electrical Steel.
CURVE A = PARALLEL GRAIN
CURVE B = HALF PARALLEL AND HALF TRANSVERSE GRAIN
PERMEABILITY
INDUCTION, GAUSSES (B)
MAGNETIZING FORCE, OERSTEDS (H)
D-c Magnetization Curves for .002-inch ARMCO Thin-Gage Electrical Steel.

## It Can be Supplied in a Width 12,000 Times Its Thickness!

Now you can get insulated electrical steel thinner than a human hair — steel of exceptional magnetic quality that is rolled to a remarkable gage-uniformity.

This is one of Armco's war-born developments that makes possible many new improvements in electrical equipment of all kinds. Peace-time uses include magnetic cores for television, high-frequency induction heating, radar, sonic detection, airborne electrical equipment and many other high-frequency devices.

If you make these or similar products, it may be possible to greatly improve their efficiency by using exceptionally thin insulated laminations in magnetic cores operating at high frequencies.

### Low Energy Loss

Low energy loss and small, compact cores are two important advantages. For example, 100 kilowatt modulators for radar systems with cores of .002-inch electrical steel now weigh only one-half pound. Earlier models had cores weighing 20 times as much.

Charts on this page show core loss vs. frequency for .002-inch silicon steel, and a d-c magnetization curve at low induction. Write us for other information pertaining to your specific products. Just address The American Rolling Mill Company, 681 Curtis Street, Middletown, Ohio.

*The American Rolling Mill Company*

ELECTRICAL ★ ARMCO ★ SHEET STEELS

Look first to ARMCO for Special-Purpose Electrical Steels

*Designed for*

*Application*

***The No. 90881***

**RF POWER AMPLIFIER**

This "500" watt, RF power amplifier unit may be used as the basis of a high power amateur band transmitter or as a means for increasing the power output of an existing transmitter. As shipped from the factory, the No. 90881 RF power amplifier is wired for use with the popular RCA or G.E. "812" type tubes, but adequate instructions are furnished for re-adjusting for operation with such other popular amateur style transmitting tubes as Taylor TZ40, Eimac 35T, etc. The amplifier is of unusually sturdy mechanical construction, on a 10½" relay rack panel. The panel contains the grid and plate tank tuning capacitor dials, as well as the grid and plate current milliameters. Plug-in inductors are available for operation on 10, 20, 40 or 80 meter amateur bands, from stock, as well as special coils to order for commercial frequencies. The standard Millen No. 90800 exciter unit is an ideal driver for the new No. 90881 RF power amplifier.

**JAMES MILLEN MFG. CO., INC.**

MAIN OFFICE AND FACTORY

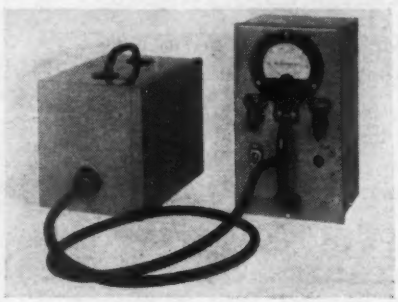
MALDEN

MASSACHUSETTS

resistive loads has an operating time of one millisecond or less. Contact rating is 0.5 ampere at 110 volts. Because of its shock-absorbing mechanism, the relay can be used as a square-wave generator by applying a-c to the coil and d-c to the contacts. Catalog 105A gives complete details.

### Light Meter (25)

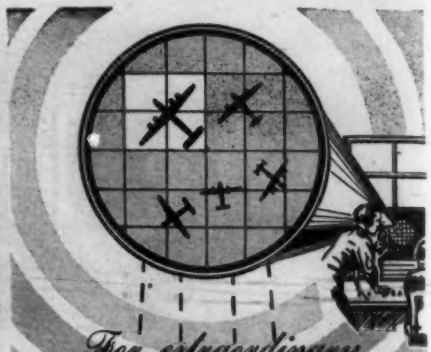
THE BARTON CO., 968 Farmington Ave., West Hartford, Conn. The model 623 light meter provides a means of measuring relative light intensites of low magnitude in the blue portion of the light spectrum,



and has been designed particularly in checking the operation of photo-electric lighting controls employing blue-sensitive tubes. A calibration chart and auxiliary light tunnel used with the meter allow adjustment of street lighting controls.

### Twin Power Supply (26)

FURST ELECTRONICS, 800 W. North Ave., Chicago 22, Ill. The electronically regulated twin power supply,

*For extraordinary electrical performance*

**Use SILVER GRAPHALLOY***

GRAPHALLOY

TRADE MARK REG. U. S. PAT. OFF.

THE SUPREME CONTACT MATERIAL

**in BRUSHES**
**for high current density ● minimum wear ● low contact drop ● low electrical noise ● self-lubrication**

**in CONTACTS**
**for low resistance ● non-welding character**

GRAPHALLOY works where others won't! Specify GRAPHALLOY with confidence.

*A special silver-impregnated graphite

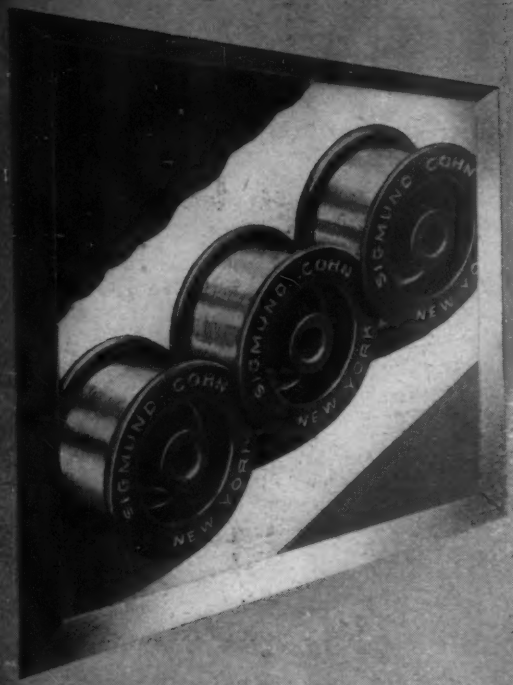
**GRAPHITE METALLIZING CORPORATION**

1055 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

MICRODIMENSIONAL

WIRE & RIBBON

FOR VACUUM TUBES




Wires drawn to .0004" diameter.

•

Ribbon rolled to .0001" thickness.

•

Special Alloys for individual requirements.

•

WRITE for list of stock alloys.

SIGMUND COHN & CO.

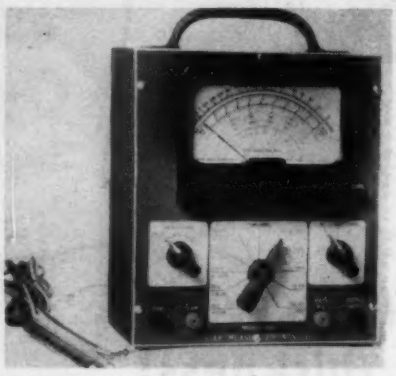
44 GOLD ST. NEW YORK

SINCE 1901

model 210 features two independent adjustable output voltages that remain constant regardless of variations in the power line and load connected to each output. A selector switch allows connection of the supplies in series or parallel. An unregulated output of 6.3 volts is also available.

### Test Meter (27)

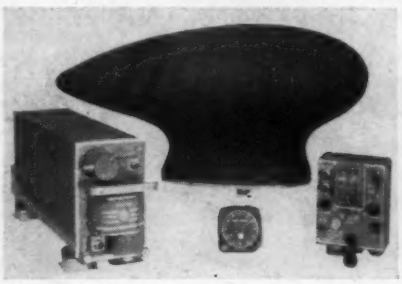
STAR MEASUREMENTS CO., 442 East 166th St., New York 56, N. Y. The model M-11 tester is a volt-ohm-milliammeter with voltage ranges



up to 1,000 volts on both a-c and d-c. Current ranges up to one ampere and resistance ranges up to 5 megohms are also incorporated. In all, twenty-seven separate ranges are available. Batteries are enclosed in the metal cabinet.

### Direction Finder (28)

RADIO CORP. OF AMERICA, Camden, N. J. The type AVR-21 automatic direction finder consists of four



★ The improved, tougher Type 58 C... stat wire-wound control provides ... other notable advantages, a neat, ... rugged, still more effective tandem ... assembly as here shown. Available ... or without power switch.

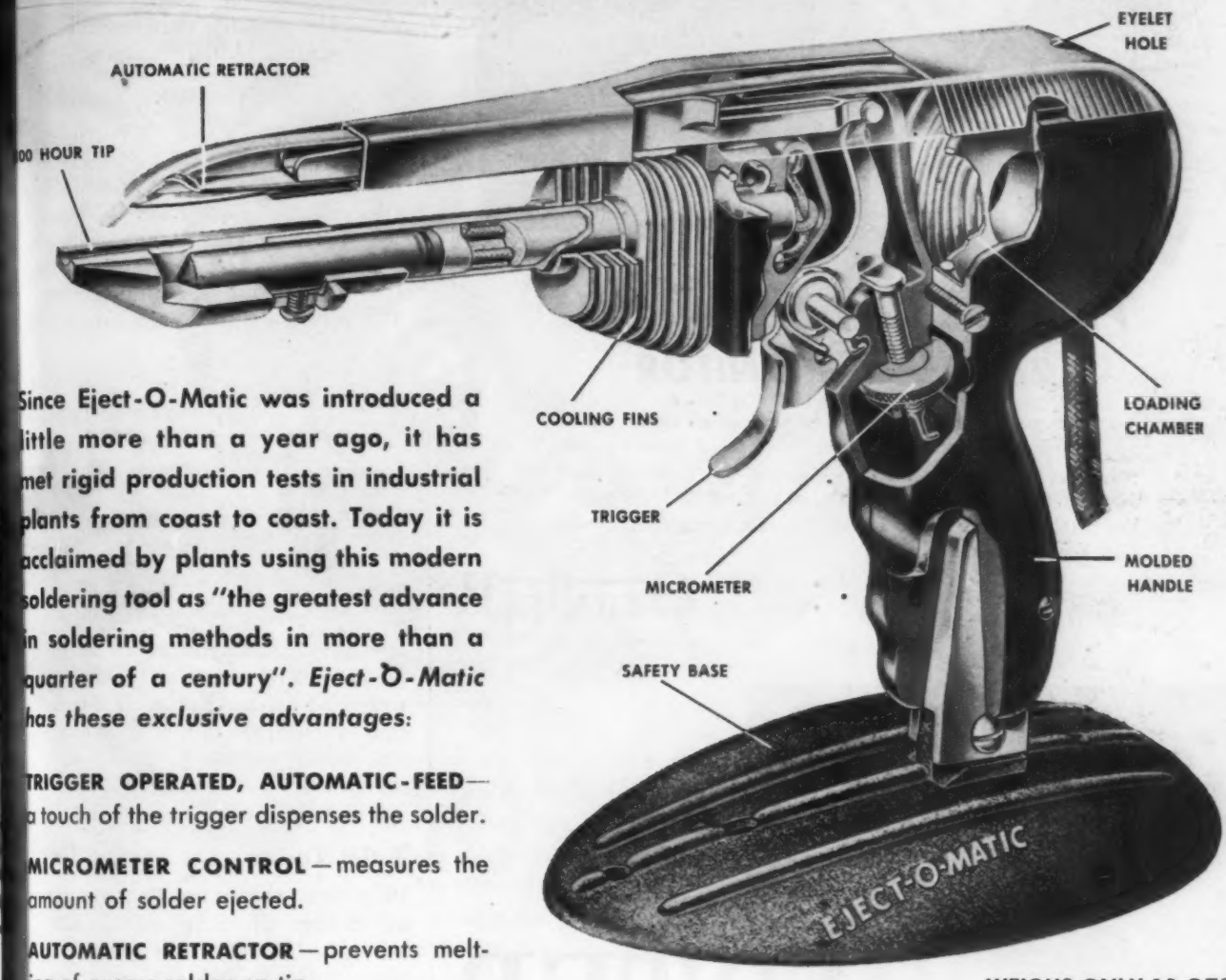
Metal locating pin on front unit will ... break or tear off. Bushing, keyed into ... bakelite case, cannot slip or turn ... locking nut is drawn up tightly. 1500 ... breakdown insulation between wind... and shaft. Each center rail is in ... piece with its terminal. Direct connec... between winding and "L" and "R" ... minals. Thus a real good dual contro... made still better with these improved ... 58 units.

CLAROSTAT

Contro... Resist...

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn

# the inside story OF AMERICA'S MOST EFFICIENT SOLDERING IRON




**Since Eject-O-Matic was introduced a little more than a year ago, it has met rigid production tests in industrial plants from coast to coast. Today it is acclaimed by plants using this modern soldering tool as "the greatest advance in soldering methods in more than a quarter of a century". *Eject-O-Matic* has these exclusive advantages:**

**TRIGGER OPERATED, AUTOMATIC-FEED**—a touch of the trigger dispenses the solder.

**MICROMETER CONTROL**—measures the amount of solder ejected.

**AUTOMATIC RETRACTOR**—prevents melting of excess solder on tip.

**400-HOUR TIP, MULTI-CLAD**—non-corroding, never needs filing or tinning.

**COOLING FINS**—keep tip at proper working temperature—no thermostat required.

**LOADING CHAMBER**—easily accessible, holds 4 oz. reel of solder.

**EYELET HOLE**—permits automatic feeding of solder from large rolls mounted on, or under, bench.

**MOLDED HANDLE**—made of heat-resistant plastic.

**SAFETY-UTILITY BASE** — provides resting place for idle or cooling iron.

**WEIGHS ONLY 18 OZS.**

***Write for descriptive literature or, if you wish, we shall be glad to arrange for a demonstration.***

Available in 50, 75, 100 and 150 watt models. Tips in 6 different sizes and shapes.

Individually packed. Shipping weight per carton of 12 units, approximately 35 lbs.

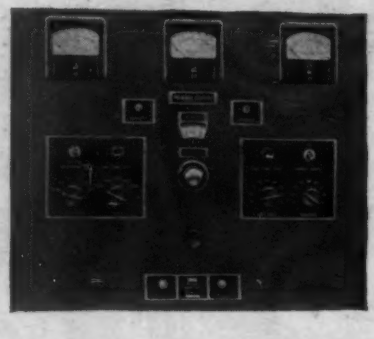
AUTOMATIC-FEED SOLDERING TOOL

**EJECT-O-MATIC**

HOUSES · MEASURES · EJECTS THE SOLDER

**MULTI-PRODUCTS TOOL** COMPANY, 123 SUSSEX AVENUE, NEWARK 4, NEW JERSEY

SIT BACK AND RELAX WITH ASSURANCE



. . . install a

**Western Electric**

**2A PHASE MONITOR**

You just can't beat the 2A Phase Monitor as an aid for quick, accurate adjustment and monitoring of directional antenna arrays.

No matter what your antenna control or coupling problems, you'll find that Western Electric has the units to solve them efficiently. For details, write Graybar Electric Co., 420 Lexington Avenue, New York 17, N. Y., or . . .

ASK YOUR LOCAL **GraybaR**
BROADCAST REPRESENTATIVE

POTENTIOMETERS
JACKS
RHEOSTATS
RESISTORS
PHONE PLUGS
SWITCHES
SWITCH STACK ASSEMBLIES
"T" AND "L" PAD ATTENUATORS

**CARTER**
**RADIO DIVISION**
*"Twenty-five years of service to industry"*

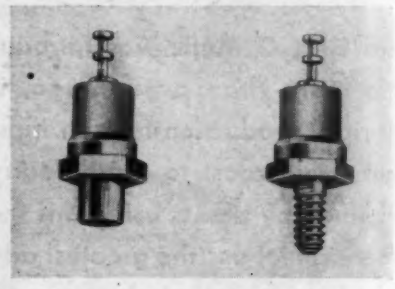
**CARTER RADIO DIVISION**
PRECISION PARTS CO.
213 Institute Place
Chicago 10, Illinois
*Write for full details and catalogue today*




components for airline use. The receiver contains its own power supply and can be mounted in any convenient location. The azimuth indicator shows the position of the enclosed loop. The pilot's control box contains the station indicator and the necessary switches for remote control.

### Terminal Lugs (29)

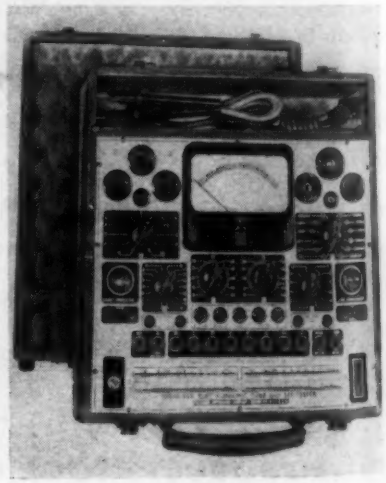
CAMBRIDGE THERMIONIC CORP., 445 Concord Ave., Cambridge 38, Mass. New insulated midget terminal lugs are furnished in both rivet and stud type with 6,000-volt a-c breakdown. The primary uses of the insulated



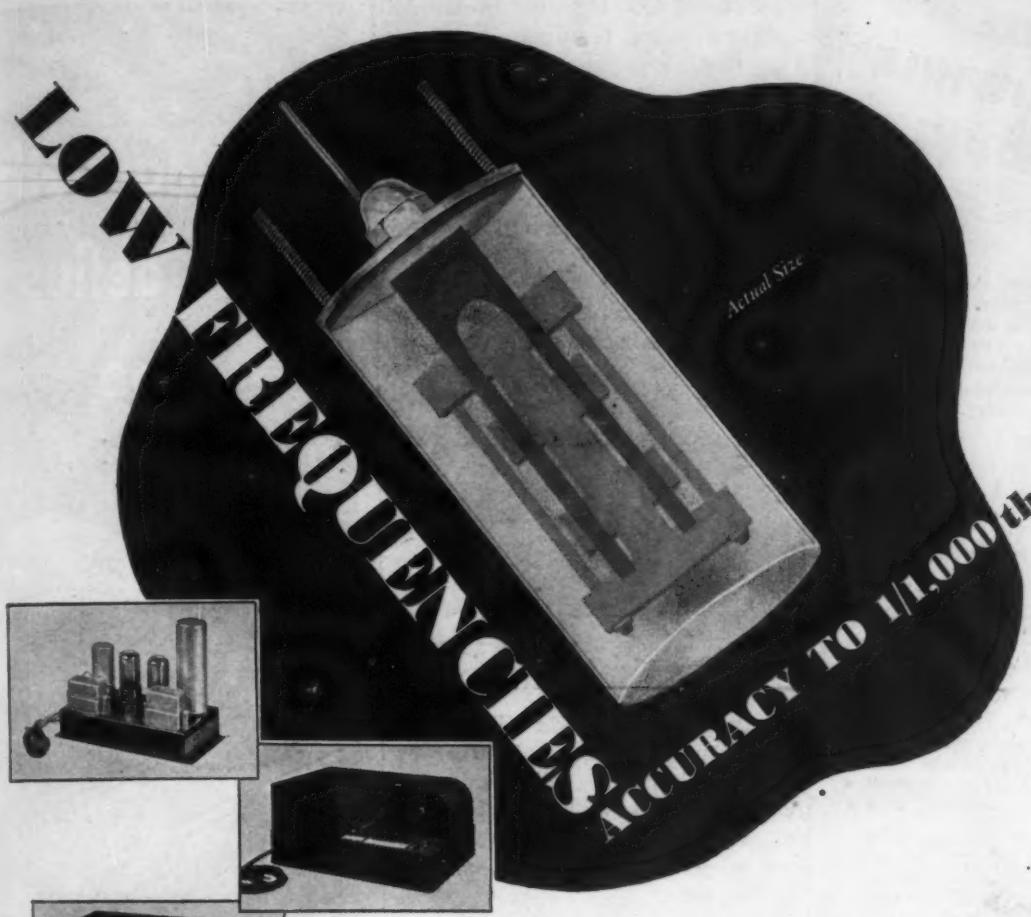
lugs cover such applications as tie-points where potential is high or where r-f exists. Further information is contained in a catalog available through Dept. 4.

### Tube Tester (30)

PRECISION APPARATUS CO., Inc., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y. The type 954-P tube, battery, and set tester includes a mutual-conductance vacuum tube checker and a 37-range a-c and d-c meter. Voltages



# LOW FREQUENCIES ACCURACY TO 1/1,000th of 1%




*TOP*
*FREQUENCY STANDARD*
*(60 cycle) for use with external power supply*

*CENTER*
*CHRONOGRAPH*
*Records time intervals with resolution to .001 second*

*BOTTOM*
*FREQUENCY STANDARD*
*(120 cycles) with self-contained power supply*

**These tuning forks which include new engineering principles, provide frequencies from 120 to 1,000 cycles directly with an unqualified guarantee of accuracy to 1 part in 100,000 over a wide temperature range. (Better than 1 second in 24 hours). Closer tolerances are obtainable on special order.**

**These tuning fork assemblies are available only in single or multi-frequency instruments of our own manufacture which are designed to test, measure or control other precision equipment by mechanical, electrical accoustical or optical means.**

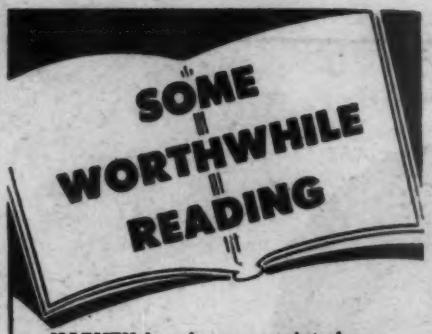
**The dependability of these frequency standards is being demonstrated for myriad purposes in all climates and under all working conditions.**

**If you have need for low frequency standards of exceptional accuracy, your inquiries are invited.**

## American Time Products, Inc.

**580 Fifth Ave.** **New York, N. Y.**

*Dist. of* Western Electric & *Watch Master* Watch-rate Recorders

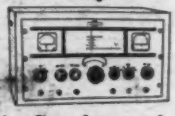



**HARVEY has been appointed authorized dealer for the new Collins line of transmitters and receivers. These units are precision built to the highest standards. We are now taking orders on the whole line for quick delivery.**

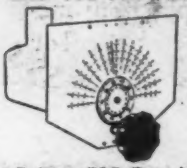
**The Model 30K-1 Transmitter, complete with the 310A-1 Exciter and all tubes, is a complete transmitter ready to operate. Input is 500 watts on cw, 375 watts on phone. Operating controls in Exciter unit.**

**$1250**

**32V-1 150-watt transmitter (120 watts on phone) complete with tubes. Uses the highly stabilized and accurate Collins VFO. $475**



**70E-8 VFO. It is new, versatile and extremely accurate. Overall accuracy and stability are within 0.015%. Can be used for all bands up to ⅔ meter with doublers. Complete with calibrated dial. You can build a good band-switching exciter unit with the 70E-8 that will make multi-band operation a pleasure. $40.00**



**Collins 75A Receiver. The receiver to end all receivers! 80-40-20-15-11-10 meter bands. Straight line tuning. Dial calibrated in frequency. 50db image rejection on all bands, uses double conversion. Permability tuned, extremely high stability, uses separate oscillator for mixers. Complete with tubes, crystals and speaker. $375**

**Send your order in now for earliest delivery. All prices quoted are Net, F.O.B. New York and are subject to change without notice.**

**Telephone: LOngacre 3-1800**

**hrc HARVEY RADIO COMPANY INC.**

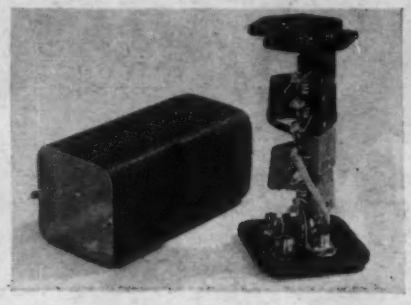
**103 West 43rd St., New York 18, N. Y.**




up to 6,000 can be measured. Among other features, resistance up to 60 megohms and db ranges up to plus 70 can be accommodated on the instrument.

## Wien Bridge Filter (31)

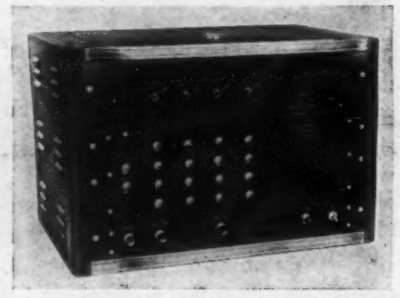
KALBFELL LABORATORIES, 1076 Morena Boulevard, San Diego 10, Calif. A Wien bridge filter designed to cancel 60 and 120 cycle hum when using an oscillograph or vacuum-tube voltmeter consists of



two bridges in cascade. Terminals are brought out so that either or both can be used. Only fixed mica capacitors and low temperature coefficient resistors are used, the whole assembly being sealed in polystyrene.

## Counter and Control (32)

POTTER INSTRUMENT CO., 136-56 Roosevelt Ave., Flushing, N. Y. The new model 140 single-channel predetermined counter used for high-speed counting, batching, and

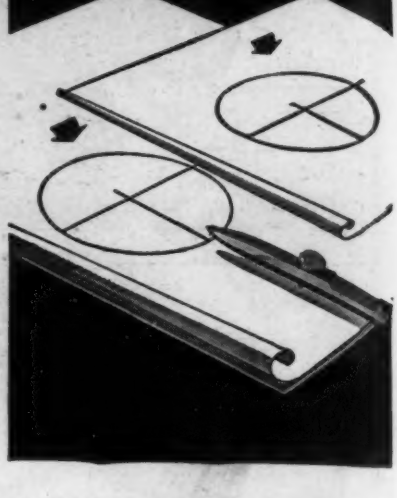


packaging control will function at rates of 15,000 per minute or higher if required. The unit utilizes four standard four-tube counter decades arranged to permit use of any predetermined number from 0 to 10,000.

## Booster Amplifiers (33)

DAVID BOGEN CO., Inc., 663 Broadway, New York 12, N. Y. Two new


**Tracing cloth that defies time**



● The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.

**IMPERIAL TRACING CLOTH**

**SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE**

# WILCO CONTACTS

## *They keep the power flowing!*

**WILCO PRODUCTS INCLUDE:**

**CONTACTS**
Silver - Platinum - Tungsten - Alloys
Sintered Powder Metal

**THERMOSTATIC BIMETAL**
All temperature ranges, deflection rates and electrical resistivities.

**SILVER CLAD STEEL JACKETED WIRE**
Silver on Steel, Copper, Invar or other combinations requested.

**ROLLED GOLD PLATE AND WIRE**

**NI-SPAN C***
New Constant Modulus Alloy

**SPECIAL MATERIALS**

*Reg. Trade Mark, The International Nickel Co., Inc.

WILCO

Modern industry utilizes WILCO CONTACTS in frequency operations of every range both because of their longer service life and because they assure maximum ductility, hardness, density, freedom from sticking, low metal transfer, high conductivity and arc-resistance.

These same peerless WILCO qualities of stamina and precision performance—assured by exclusive WILCO processes—will keep the power flowing in *your* products. WILCO engineers will gladly help you select from a great variety of available WILCO contact materials the particular contacts suited to your needs—or develop new alloys for special purposes.

**THE H. A. WILSON COMPANY**

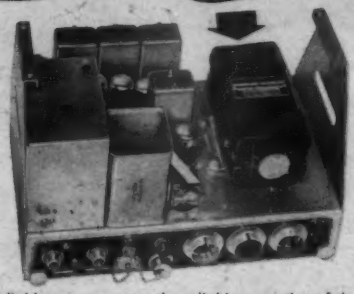
105 Chestnut Street, Newark 5, N. J. • *Branch Offices:* Chicago, Detroit, Los Angeles, Providence

**SPECIALISTS FOR 30 YEARS IN THE MANUFACTURE OF THERMOMETALS • ELECTRICAL CONTACTS • PRECIOUS METAL BIMETALLIC PRODUCTS**

"A Well Known Name in Radio for Over 20 Years"

NO. 2 OF A SERIES

Carter powers the MOTOROLA 162 MC F.M. Transmitter



Reliable power assures the reliable operation of the new *Motorola FM Mobile 162 megacycle Transmitter*...instantaneous power from the CARTER Genemotor shown on the chassis above. The *ONLY* Dynamotor that delivers full power in 3/10 second and over 100,000 service-free transmissions. **Write for latest catalog.**

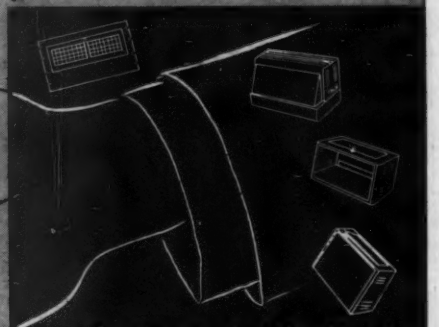
Carter Motor Co.
Chicago, Illinois

2648 N. MAPLEWOOD AVENUE • CABLE: GENEMOTOR

SPECIALIZED Skill in METAL

CABINETS

PANELS • CHASSIS • RACKS with Beautiful Chrome Trim



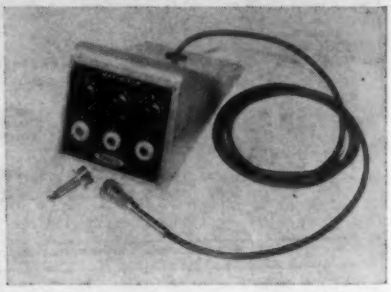
PAR-METAL PRODUCTS CORPORATION
32-62—49th STREET
LONG ISLAND CITY 3, NEW YORK
Export Dept.: Rocke International Corp.
13 East 40 Street, New York 16

The time-tested Par-Metal line presents superior features of styling, design, and construction. True to policy, Par-Metal continues to *specialize in Electronic Housings* exclusively...and is therefore able to offer leadership in value. Compare! *Write for Catalogue.*

booster amplifiers, types G050 and G0125, capable of delivering 50 and 125 watts respectively use multi-stage inverse feedback to attain a flat response within 1 db from 20 to 20,000 cycles. Input impedance is 500,000 ohms with provision for balanced-line zero-level input for use on telephone lines. The self-contained power pack provides a regulated screen supply.

### Mike Input (34)

SPECIAL PRODUCTS Co., Silver Spring, Md. The Max-Mixer is a device to enable owners of public address amplifiers to use three additional microphones and control each one at the proper level. The



unit is equipped with six feet of shielded cable for connection to the amplifier.

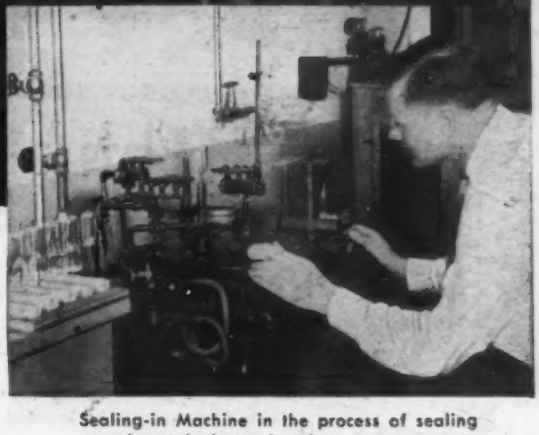
### Antenna Rotator (35)

THE WORKSHOP ASSOCIATES, Inc., 66 Needham St., Newton Highlands 61, Mass. Designed primarily for amateur transmitting antenna arrays, the new rotator can be used for other service such as f-m and television reception. Mechanically rugged, the device simplifies the electrical-connection problem by using only a 360-degree rotation that obviates the need for slip rings. The feed line can be matched without difficulty to the antenna structure. Motion of the antenna

# Practical Research DEDICATED TO Superior Electronic Tubing

Superior's Electronic Laboratory opens the doors to far reaching research and development of electronic tubing, through the study of materials, processes and controls.

The Emission Microscope, shown above, makes it possible to test the material in electronic tubes, under actual operating conditions, for emissive qualities. Material control standards, otherwise unattainable, are now realities. The way is open to important development of new tubing materials and uses.



Sealing-in Machine in the process of sealing experimental electronic tubes preparatory to emission testing.

Comparator measuring dimensions to 10 thousandths of an inch, for inspecting the quality of work going into electronic tube cathodes and parts. This is just one of many tests conducted by the "Quality Control Group" of the Superior Laboratories.

THE BIGGER NAME IN SMALL TUBING

Superior

SUPERIOR TUBE COMPANY
NORRISTOWN • PENNSYLVANIA

EVER SEE THESE?

Milford SEMI-TUBULAR Rivets—

SOLID where solidity is required for strength.

SEMI-TUBULAR to save time in setting.

MILFORD FASTENING EQUIPMENT

A pin on Milford Rivet Setters engages the semi-tubular end of the rivet, guides it home accurately and instantly to make an unbreakable assembly. Costs cut. Time saved. Production speeded. Milford designs and manufactures rivets in endless variety and makes 15 standard models of bench and floor type rivet setters (special models, to order).

MILFORD BENCH TYPE RIVET SETTER

SETS 60 RIVETS A MINUTE

in Metal, Wood, Fabric, Plastic or any combination of the four.

Send blue prints or actual sample for more information, or write for a Milford representative to call.

THE MILFORD RIVET & MACHINE CO.
859 Bridgeport Ave.
MILFORD, CONN.
1002 West River St., Elyria, Ohio

*Inquiries may also be addressed to our subsidiary:*
THE PENN RIVET & MACHINE CO. PHILADELPHIA 33, PENNA.



BRACH
ESTABLISHED 1906

ANTENNA SYSTEMS
for USERS
of PRIVATE BRANDS

We manufacture the following, under private labels and trademarks:

**AUTOMOBILE ANTENNAS** . . . every variety, including types that can be raised and lowered from inside the car.

**RESIDENTIAL ANTENNAS** . . . AM and FM, for homes, stores and multi-family buildings. Complete lines of noise-reducing systems incorporating latest patented developments of coupling transformers.

**FM, AM and TELEVISION** . . . Dipoles with or without reflectors, folded dipoles, turnstile, radiating types and other combinations for roof, sidewall and other mountings.

**MARINE ANTENNAS** . . . Collapsible and transmitting types for every purpose.

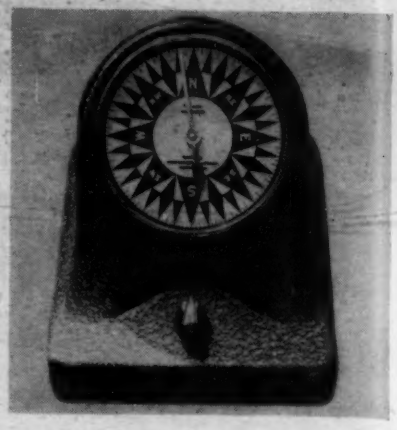
**For POLICE and other mobile units** . . . roof-top antennas for ultra-high frequencies.

WE INVITE INQUIRIES AND CONSULTATIONS.

L. S. BRACH MFG. CORP.
200 CENTRAL AVENUE NEWARK, 4 N. J.

WORLD'S OLDEST AND LARGEST MANUFACTURERS OF RADIO ANTENNAS AND ACCESSORIES

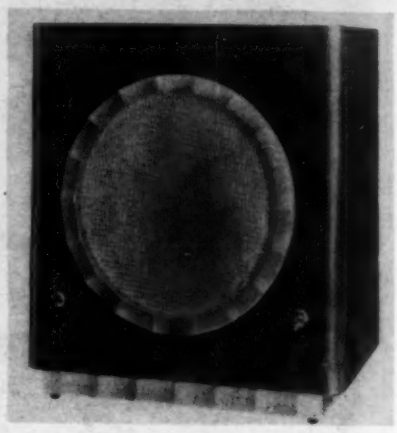


stops automatically at north. A three-position switch control is shown on the indicator base casting.

## Sound Reproducer (36)

ALLEN D. CARDWELL MFG. CORP., 97 Whiting St., Plainville, Conn. The model CE-26 sound reproducer is a combined amplifier and loud-

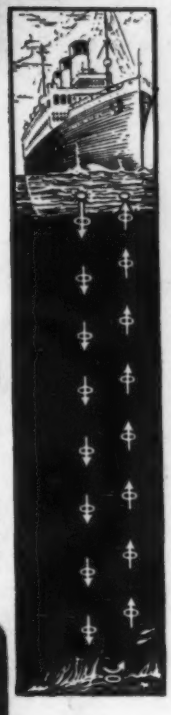


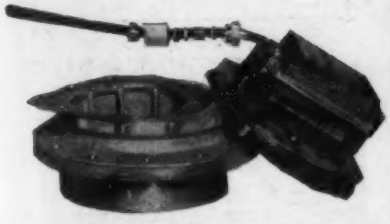
speaker designed for general use with microphone, phonograph pick-up, or guitar reinforcing system. Eight watts undistorted output is available with a frequency response flat within 2 db from 60 to 8,000 cycles.

## Capacitance Meter (37)

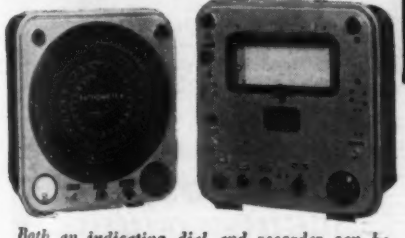
MAIDA DEVELOPMENT CO., Box 588, Erie, Pa. The model 201 direct-reading capacitance meter operates on the principle of measuring the current through a capacitor when a known voltage at 100 kilocycles is impressed across it. Ten overlapping ranges make possible measurements from 0.1 to 10,000 microfarads. Each instrument is adjusted to within 1 percent of full-scale

# METAL PLATES that serve a steady diet of sound





*One of the two oscillators that are the key parts of every Fathometer. Here, the oscillating unit has been tipped back out of its casing to show where the stack of Nickel lamination plates is mounted.*



*Both an indicating dial and recorder can be used with the Fathometer. Other components include an amplifier and a driver.*

**The FATHOMETER†—the first practical application of "Sonar"—utilizes the magnetostriction of Nickel**

One of the most practical uses of sonar is the Fathometer, manufactured by the Submarine Signal Co., Boston, Mass.

The Fathometer generates sonic vibrations, throws them at the bottom, and then listens for their echoes. With a Fathometer you can map the ocean floor . . . locate fish . . . safeguard navigation.

Like many other adaptations of sonar, the Fathometer depends upon Nickel to send and receive the sonic vibrations. Heart of each oscillator is a stack of thin Nickel plates, laced together with a winding of wire.

## HOW THE FATHOMETER WORKS

When current is passed through these windings, a magnetic field is created. *That's when the magnetostrictive property of Nickel goes to work!*

For under the influence of magnetic force, Nickel contracts, returning to its original length when the field goes dead. In a fluctuating field, the resulting vibrations are powerful enough to produce an echo from the ocean floor.

When the sonic waves bounce back to the Fathometer, a second oscillator (acting as a receiver) goes through the same cycle in reverse to convert sound into electrical impulses. Other components then time the lag between transmission and echo, registering the depth on an indicator.

## WHY NICKEL WAS CHOSEN

Nickel is used in sonar because it contracts more than other magnetostrictive metal, contracting 32 units of length for every 1,000,000.

Magnetostriction is just one of the specialized properties obtainable with Nickel. When specifying metals for electronic or electrical use always consider Nickel and the INCO Nickel Alloys. They are strong, tough, rustless, corrosion-resistant and thermally durable.

†Trademark registered by Submarine Signal Company

**THE INTERNATIONAL NICKEL COMPANY, INC.**
*67 WALL STREET, NEW YORK 5, N. Y.*

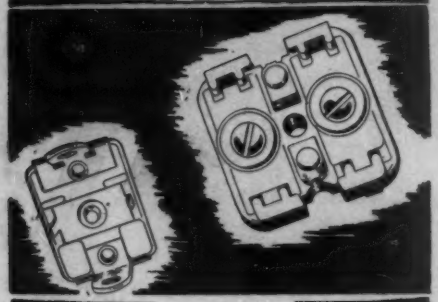
Nickel

**NICKEL (INCO TRADE MARK) ALLOYS**

MONEL* • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL* • NICKEL • "L" NICKEL • "Z" NICKEL
*Reg. U. S. Pat. Off.

Cryscons

SPINDLE VARIABLE MICA CAPACITORS



Cryscons are electronically tested to insure accurately rated minimum loss trimmers and padders.

The CN-351 series is an efficient RF trimmer capacitor. **(RF Padders in standard ranges — even to 1.5 — 7 mmf).** The CN-55 series is a dual IF padder capacitor. The latter series may also be had with two fixed series capacitors.

**SALES REPRESENTATIVES**

**CHICAGO AREA:**
P. G. RIDLEY
4804 West Chicago Avenue
CHICAGO 5, ILLINOIS

**EASTERN AREA:**
LEO FREED & CO.
420 Lexington Avenue
NEW YORK 17, NEW YORK

**PACIFIC COAST AREA:**
HARRY A. LASURE CO.
2216 West 11th Street
LOS ANGELES 6, CALIFORNIA

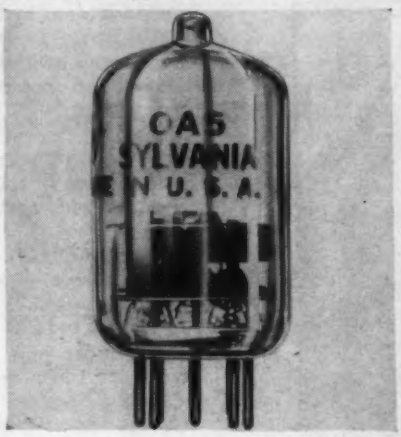
*Early deliveries for large or medium orders — Inquire regionally or directly.*

**CRYSCON, Inc.**
SUBSIDIARY OF:
CRYSTAL RESEARCH
LABORATORIES, Inc.
29 Allyn Street Hartford 3, Conn.
Telephone 7-3215

reading on all ten ranges and is guaranteed to be within 2 percent of full scale. Inductance measurements are generally within 5 percent after some computation involving apparent capacitance indication.

### Relay Tube (38)

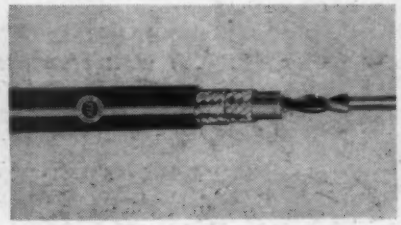
SYLVANIA ELECTRIC PRODUCTS Inc., 500 Fifth Ave., New York 18, N. Y. The cold-cathode relay tube type 0A5 measures 1⅝ inch overall and 11/16 inch in diameter. A positive trigger pulse of 85 volts is sufficient



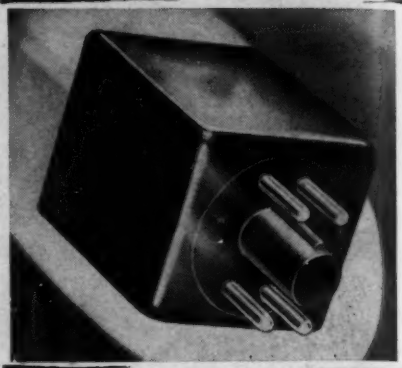

to fire the tube when the anode rests at 750 volts. The new tube has been designed for use in electronic photoflash and similar equipment.

### F-M and Television Cable (39)

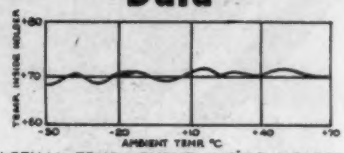
FEDERAL TELEPHONE AND RADIO CORP., Newark, N. J. Type KT-51 dual conductor twisted-pair cable is shielded by two metal braid cov-



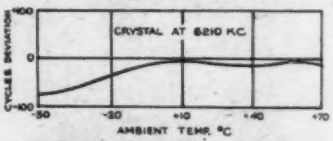

NEW IMPROVED CRYSTAL HEATER HOLDER



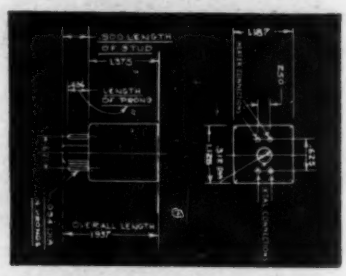
**Performance Data**




ACTUAL TEMP. CURVE INSIDE HOLDER




ACTUAL FREQUENCY CURVE



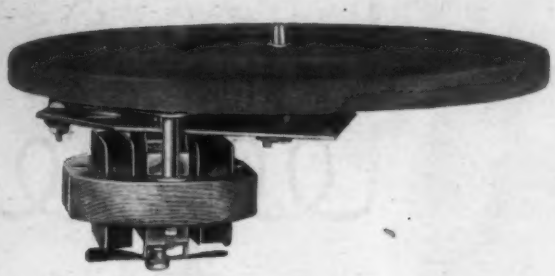
***Selectronic*** **XL-30 is designed for close frequency tolerance . . . VHF services . . . police, aircraft, railway communications, etc. Heater works at 6 volts, 1 amp. Frequency range: 3,000 KC to 15,000 KC.**

***ENGINEERS OF SELECTRONIC CRYSTALS***

CRYSTAL RESEARCH
LABORATORIES, Inc.
29 Allyn Street Hartford 3, Conn.
Telephone 7-3215

- PHONOGRAPH-TURNTABLE UNITS
- FRACTIONAL HORSEPOWER MOTORS
- PRECISION WIRE WOUND RESISTORS
- RADIO AND ELECTRONIC TEST EQUIPMENT

# Eastern Electronics Corp.



## PHONOGRAPH TURNTABLE UNIT

***Engineers will find this compact turntable meeting all of their requirements.***

PERFORMANCE:—Correct and uniform speed is secured through the use of a motor of ample capacity, preloaded to operate on the flattest portion of the torque-speed characteristic.

QUIETNESS:—Is assured by full-floating rubber motor mountings and rubber cushioned drive. Permanent freedom from turntable wobble is guaranteed by an extra rigid turntable, an extra long bearing and precision machining of these parts.

Unit can be supplied for 110 volt and 220 volt 50 or 60 cycle operation.

Deliveries prompt.

## FRACTIONAL HORSEPOWER MOTORS

Sturdy motors, precision built for long life and rugged requirements.

Single phase shaded pole induction type suitable for many applications. Constant speed is maintained through the use of new shading design making this motor ideal for use where good starting torque requirements are needed.

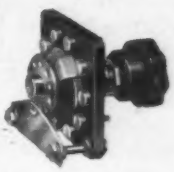
Dual motor coils of ample turns impregnated against moisture will operate continuously with an exceptionally low temperature rise.

Bearings are of ample size and are self-aligning with self-lubricating features.

Production starts soon and we invite inquiries now as to your 1947 motor requirements.

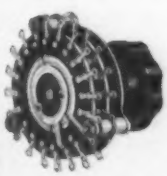
## ROTARY SELECTOR SWITCHES

### FOR THE CRITICAL ENGINEER



- TYPE XC—Single or multiple decks. Instrument type. Contact Resistance less than .001 ohm. Ideal for shunt ammeter, thermo couple type measuring equipment and Wheatstone Bridges.

SERIES EE-14—Single or multiple decks. One to six. 14 circuits each deck. Shorting or non-shorting contacts. Recommended for use in quality test equipment or accurate switching of multi-circuits with low contact loss.



SERIES EE-20—Similar to Series EE-14 but with 20 circuits each deck. Contacts and moving parts heavy coin silver plated to meet 200 hour salt spray test. Low leakage laminated plastic decks selected for maximum mechanical and dielectric strength.

*Write for catalogue*

# Eastern Electronics Corp.

41 CHESTNUT STREET, NEW HAVEN, CONN.

BRADLEY

COPPER OXIDE RECTIFIERS

IDEAL FOR AUTOMATIC CURRENT CONTROL

"Coprox" rectifiers may be your answer to more efficient current control. Their varistor characteristics make them ideal for automatic current valving, current limiting, current blocking, as well as current measurement.

Bradley rectifiers are designed to give you trouble-free service. Their electrical characteristics remain stable indefinitely When operated within normal rating, their life is unlimited.

Send for curves showing current, voltage, resistance and temperature characteristics of Bradley copper oxide rectifiers.

Illustrated literature, available on request, shows more models of copper oxide rectifiers, plus a line of selenium rectifiers and photocells. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

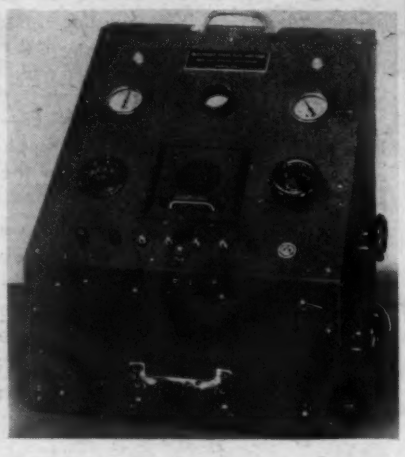
82 Meadow St. New Haven 10, Conn.



erings. A noncontaminating jacket covers the shield. Characteristic impedance of the cable is 95 ohms. Attenuation per 100 feet is 1.7 db at 30 megacycles, 3.6 at 100 mc and 10.0 db at 400 mc.

### High Voltage Tester (40)

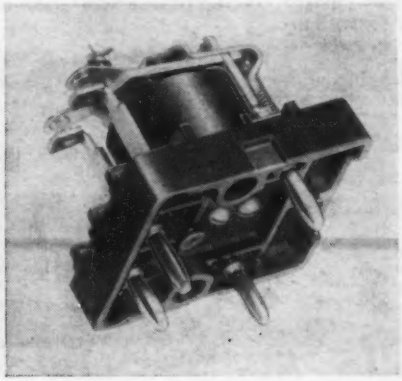
ROWE RADIO RESEARCH LABORATORY Co., 2422 North Pulaski Road, Chicago 39, Ill. The type SP22 electronic spark plug analyzer uses an oscillographic technique that is easily interpreted by inexperienced



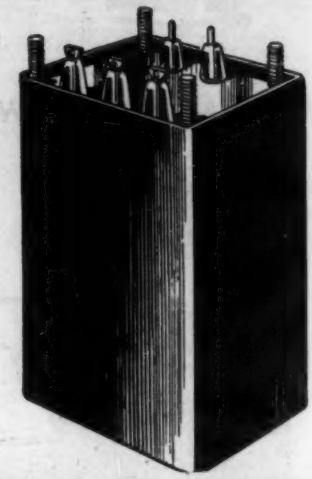
personnel. Tests at peak voltages between 1,000 and 21,000 volts can be rapidly determined. The instrument can be modified for testing high tension cable or for other resistance, corona and breakdown testing. The unit measures 20x20x22 inches.

### Plug-In Relays (41)

WARD LEONARD ELECTRIC Co., 31 South St., Mount Vernon, N. Y. Bulletin 106 magnetic relays feature pin-plug connections. They are suitable for a-c or d-c operation on standard frequencies and voltages up to 125 volts. Single-break rat-



From out of the west... America's finest transformers



Thermador is a name remembered when the utmost in transformer quality is desired, and when exceptional engineering skill is required.

"Seven Leagues Ahead"

THERMADOR

THERMADOR ELECTRICAL MFG. CO.

5119 District Blvd., Los Angeles 22, California

# *Number, Please...* Big Numbers!

*When America switched to the monophone telephone in 1925, millions were needed—quick. The job called for complex molds—presses to handle heavy pieces—ample production. Kurz-Kasch did it first.*

Many firms and individuals have contributed to the amazing advances of the plastics industry. As this series of ads testifies, Kurz-Kasch and its engineers have played their parts since the very earliest days.

We mention it only because yesterday's achievements are your promise of added competence today—because by choosing Kurz-Kasch as your molder now, your production will benefit *ahead of time* from many of the improvements of tomorrow. And that pays off.

Investigate our complete molding service. Write for your free copy of "A Businessman's Guide to the Molding of Plastics"—or ask for an engineer.

# Kurz-Kasch

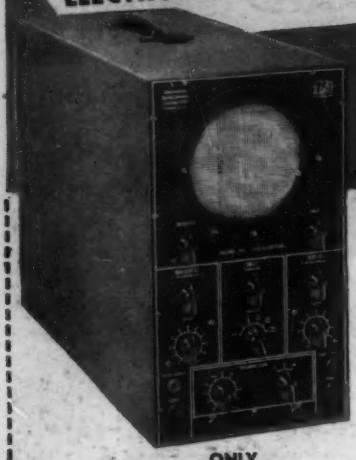
*For Over 29 Years*
*Planners and Molders in Plastics*

Kurz-Kasch, Inc., 1425 S. Broadway, Dayton 1, Ohio. *Export Offices:* 89 Broad Street, New York, N. Y.
*Branch Sales Offices:* New York • Chicago • Detroit • Los Angeles • Dallas • St. Louis • Toronto, Canada.

NEW!

ELECTRONIC DEVELOPMENT 5" OSCILLOSCOPE

For PRECISION OBSERVATION of Radio, Sound, Television and other Electronic Phenomena



This new 5" Cathode Ray Oscilloscope is a precision instrument at an attractively low price, designed for practical application in laboratory research and production work. Sturdily built to stand up under continuous use, and ably engineered for accuracy, versatility and easy operation. Has wide frequency range, 10 cycles to 300 Kc. Deflection sensitivity, 1 volt RMS per inch. Sweep range, 10 cycles to 60 Kc. in four steps. For 110-120 volt, 50-60 cycle operation. In welded steel cabinet, with baked black wrinkle-finish; 8½" wide, 14½" high, 18½" deep. Instrument panel in black, with white designations; has removable calibrated plastic scale. Complete with tubes. *No. 84-376. Net Only.* **$99.50**

STOCK NO. 84-376 ONLY $99.50

*Order from the Central Source for Everything in Radio and Electronics*

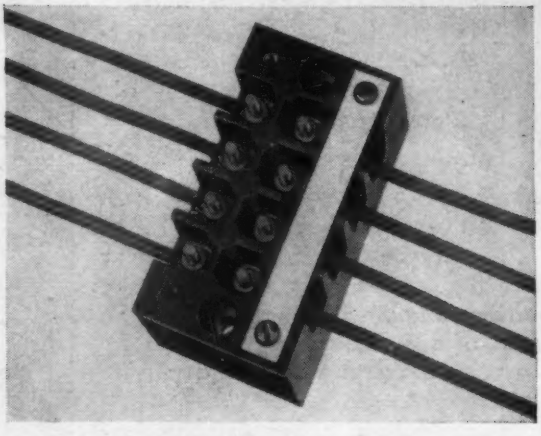
Send for ALLIED Catalog No. 111

**ALLIED RADIO CORP.**

833 W. Jackson Blvd., Dept. 24-B-7, Chicago 7, Illinois

**IMPERVIOUS to MOISTURE**

BURKE Bakelite blocks are uniformly dense due to high pressure in hardened steel moulds in electrically heated and operated moulding presses. They feature high resistance to moisture and electricity.



**SERIES 3000** features a center barrier moulded-in construction for extra mechanical strength. Center barrier off center to permit the use of terminal lugs on one side.

★ *Write for New Booklet*

to 1172 West 12th St., Erie, Pa.

AC AND DC MOTORS AND GENERATORS

**BURKE *Terminal* BLOCKS**

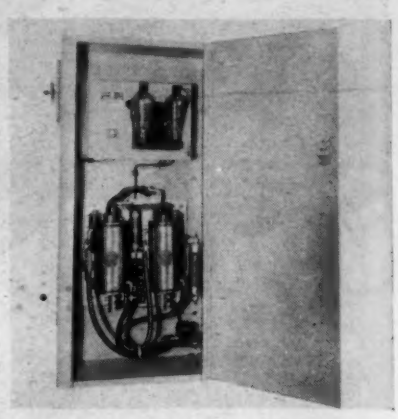
BURKE ELECTRIC COMPANY • ERIE, PENNSYLVANIA



ings are 4 amperes, 125 volts, 60 cycles on noninductive loads.

### Resistance Welding Control (42)

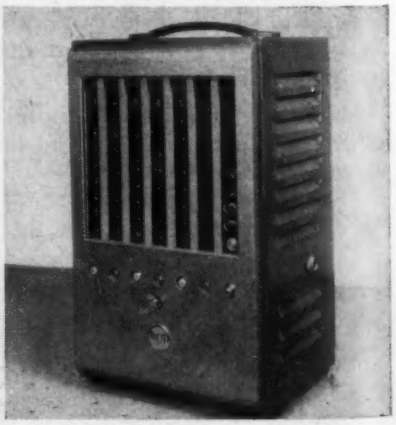
GENERAL ELECTRIC CO., Schenectady, N. Y. A new line of nonsynchronous electronic resistance welding control combinations designed to meet new NEMA stand-



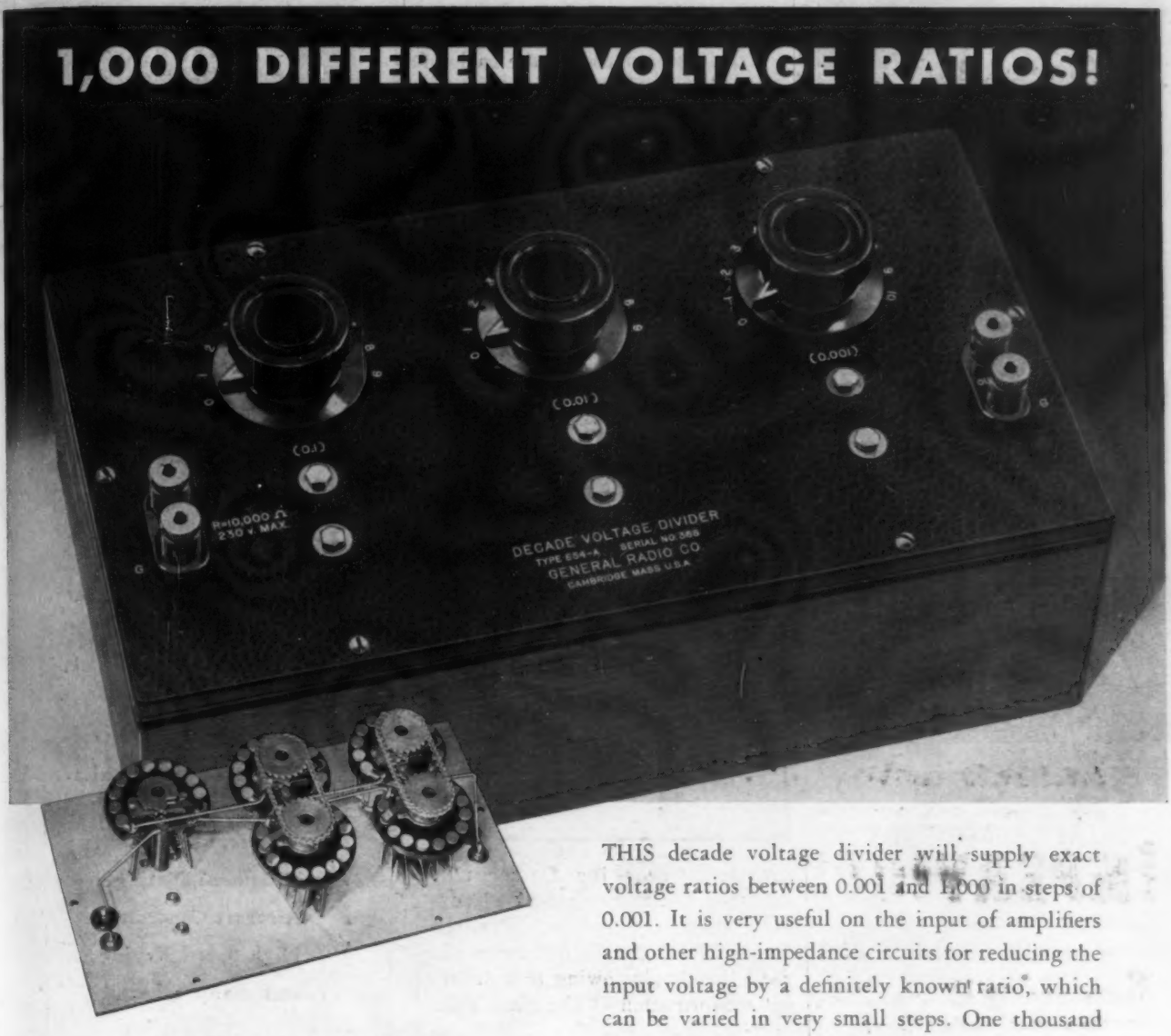
ards includes ignitron contactors and sequence-weld timers. The control cabinet illustrated can be mounted on a welder and requires only the connection of air and water lines in addition to power.

### Interval Counter (43)

RADIO CORP. of America, Camden, N. J. The type WF-99B time interval counter gives direct visual indication of the time elapsed between two impulses each of extremely short duration. Maximum time that can be accommodated is one second, in microsecond increments. The equipment can be initiated by simple mechanical switches or triggers by inertialess means such as phototube equipment. Op-



# 1,000 DIFFERENT VOLTAGE RATIOS!




THIS decade voltage divider will supply exact voltage ratios between 0.001 and 1.000 in steps of 0.001. It is very useful on the input of amplifiers and other high-impedance circuits for reducing the input voltage by a definitely known ratio, which can be varied in very small steps. One thousand different ratios can be obtained.

The input resistance remains constant regardless of dial settings, consequently reaction on the input voltage is eliminated.

The instrument is equivalent to a pair of our type 602 Decade-Resistance Boxes connected in series and so arranged mechanically that as resistance is taken out of one box it is added to the other to maintain the total resistance constant at 10,000 ohms.

All resistors are wound with an alloy wire of such characteristics that no difficulty from thermal emf will be encountered in direct-current measurements.

**TYPE 654-A DECADE VOLTAGE DIVIDER ... $100**

### ABRIDGED SPECIFICATIONS

**ACCURACY:** each resistor is adjusted within ±0.1%, error in voltage never exceeds ±0.2%

**INPUT IMPEDANCE:** constant resistance of 10,000 ohms regardless of ratio setting

**OUTPUT IMPEDANCE:** varies from 10 to 10,000 ohms, depending upon settings

**FREQUENCY CHARACTERISTIC:** if external capacitance across output terminals is less than 20 micromicrofarads, frequency error is less than 0.1% below 10,000 cycles

**TEMPERATURE COEFFICIENT** of resistors is less than ±0.002% per deg. C at normal room temperature

**AT THE MOMENT WE HAVE A FEW IN STOCK**

**WRITE FOR COMPLETE DATA**

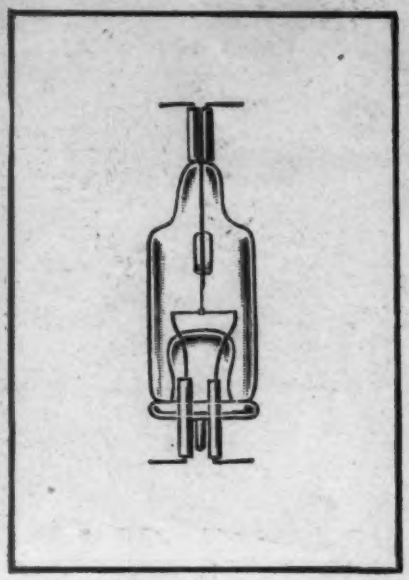
**GENERAL RADIO COMPANY** Cambridge 39, Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 950 N. Highland Ave., Los Angeles 38

erations can be automatically started and stopped on the basis of a predetermined number of items or counting impulses.

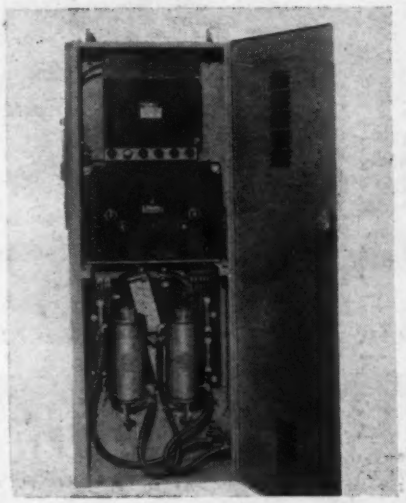
### Vacuum Thermocouple (44)

FIELD ELECTRICAL INSTRUMENT CO., 109 East 184th St., New York 53, N. Y. The type U vacuum thermocouple illustrated represents an improvement over the former unit designed for measurement of current, voltage, power at ultrahigh frequencies. Chief difference is reduction in size owing to a different conformation of the glass bulb.



### Welding Controls (45)

GENERAL ELECTRIC CO., Schenectady, N. Y. The complete line of synchronous precision controls for resistance welding machines has



HALLOWELL

**"SOCKET SCREW" KIT**
**with interchangeable bits**

For men who like to have a complete supply of tools, yet dislike bulk and confusion, the Hallowell "Socket Screw" Kits are the answer. Their hollow, durable plastic handles hold interchangeable *steel* bits for most all purposes . . . Phillips, Hex and Flat. They each have a swivel bit-chuck, which locks securely in five positions.

The "Socket Screw" Kit comes in 2 sizes: small #25 Kit; and the large #50 Kit.

Other Hallowell Kits: "Socket Wrench"; "Auto"; "Home".

Obtainable at Dealers throughout the country. If none near you, or he is sold out, send his name to us, along with yours, and you will be taken care of promptly.

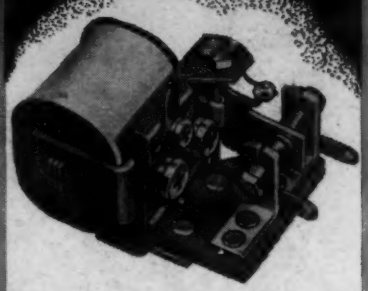
Kits: Patents Pending

*An ideal gift or prize*

Over 43 Years in Business

**STANDARD PRESSED STEEL CO.**
JENKINTOWN, PENNA., BOX 596
Boston • Chicago • Detroit • Indianapolis
St. Louis • San Francisco

REQUIRE
*Relays?*



**SIGMA**
***SENSITIVE RELAYS***
have proven themselves in countless applications:

- ✔ Temperature Control
- ✔ Vacuum Tube Circuits
- ✔ Fire and Burglar Alarms
- ✔ Telephone Dialing
- ✔ Aircraft Controls
- ✔ High Speed Keying

. . . and many others.

***Specify***
**SIGMA!**

SIGMA'S specialty is the combination of a fine relay and an unusually thorough approach to your specific application problem.

SIGMA standard relays are available with various enclosures including fixed mountings, 5-pin, and octal male plug bases.

New relays are being developed for special purposes. Send your requirements to SIGMA for dependable relay recommendations.

SIGMA
**Sigma Instruments, INC.**
*Sensitive* RELAYS
**62 Ceylon St., Boston 21, Mass.**

VARFLEX CORPORATION, manufacturer of electrical insulation,

invites you to—

# Test these Free Samples

***See for yourself how new developments can give you better electrical insulation***

● Varflex Corporation wants every manufacturer of electrical equipment to have one of these new folders. Each one contains actual working samples of 20 different types of sleeving and tubing, including *Varglas Silicone*, which was developed during the war to meet temperature variations from −85° F. to 500° F.

**Write for this folder containing test samples today.**

**Varflex CORPORATION**

*Makers of Electrical Insulating Tubing and Sleeving*

Varflex Corporation, 308 N. Jay St., Rome, N. Y.

Please send me your FREE folder containing 20 different types of electrical insulation. I am particularly interested in samples suitable for.....

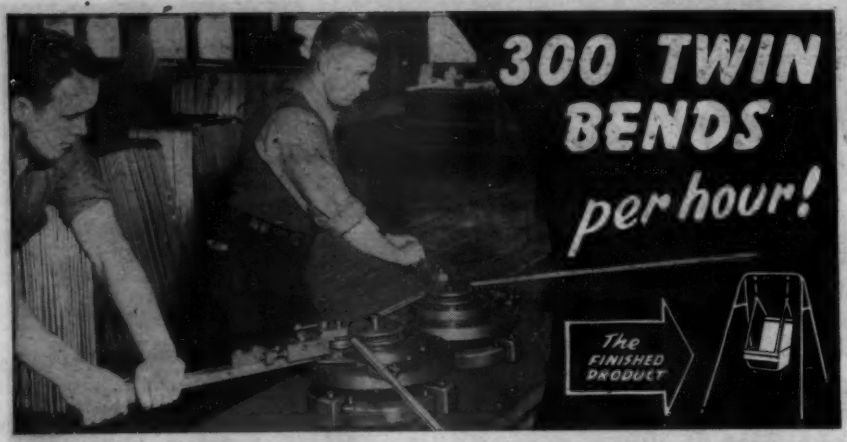
.....

Name.....

Company.....

Street.....

City.....State.....




# With Two DI-ACRO BENDERS

A difficult production problem of forming two bends in a long length of tubing was solved by "teaming up" two DI-ACRO Benders as illustrated. This dual-forming arrangement saved installation of special machinery. Two accurately formed bends are obtained in one operation—without distortion of the tube and at a cost competitive to power operated equipment. More than 300 pieces are completed per hour—600 individual bends.

**"DIE-LESS DUPLICATING" Often Does it Quicker WITHOUT DIES**

This is but one example of how DI-ACRO precision machines—Benders, Brakes and Shears—can accurately and economically duplicate a great variety of parts, pieces and shapes, without die expense.

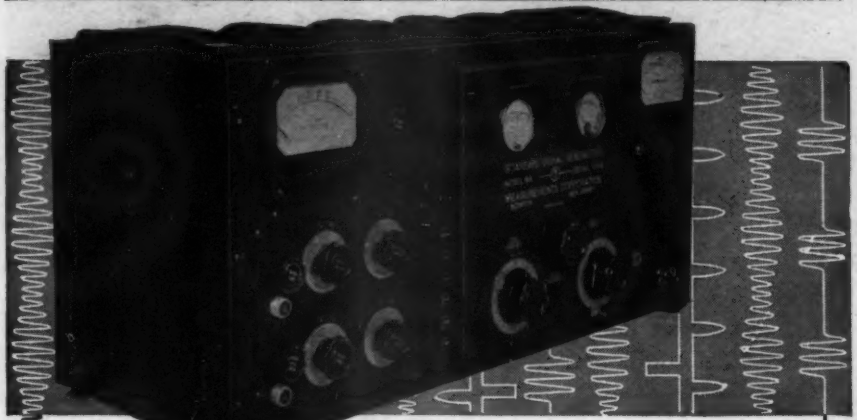
Write for Catalog—"DIE-LESS DUPLICATING"

◀DI-ACRO is pronounced "DIE-ACK-RO".

DI-ACRO PRECISION MACHINES DIE-LESS DUPLICATING

O'NEIL-IRWIN MFG. CO.

321 EIGHTH AVENUE • LAKE CITY, MINNESOTA



Laboratory Standards

# U.H.F. STANDARD SIGNAL GENERATOR *MODEL 84*

**SPECIFICATIONS**

**CARRIER FREQUENCY:** 300 to 1000 megacycles.

**OUTPUT VOLTAGE:** 0.1 to 100,000 microvolts.

**OUTPUT IMPEDANCE:** 50 ohms.

**MODULATION:** SINEWAVE: 0—30%, 400, 1000 or 2500 cycles. PULSE: Repetition—60 to 100,000 cycles. Width—1 to 50 microseconds. Delay—0 to 50 microseconds. Sync. input—amplifier and control. Sync. output—either polarity.

**DIMENSIONS:** Width 26", Height 12", Depth 10".

**WEIGHT:** 125 pounds including external line voltage regulator.

MEASUREMENTS CORPORATION

BOONTON • NEW JERSEY




been redesigned. The representative system illustrated comprises ignitron contactors, sequence controls for electrodes, and a synchronous weld timer, all components meeting new NEMA standards.

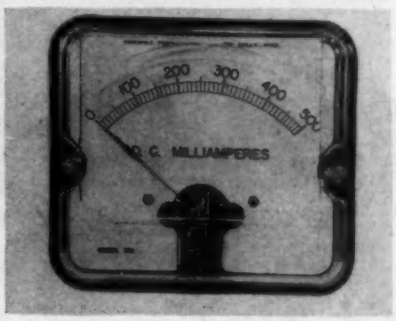
## Counting-Rate Meter (46)

GENERAL RADIO CO., 275 Massachusets Ave., Cambridge 39, Mass. A counting-rate meter and Geiger counter are available for both qualitative and quantitive observation

of radioactive materials and cosmic radiation. A loudspeaker is provided for the former and either a meter or an ink recorder can be used to count rates from 5 to 20,000 a minute.

## Plastic Case Meter (47)

ASSEMBLY PRODUCTS INC., Main and Bell St., Chagrin Falls, Ohio. A line of panel meters in clear plastic cases is now available. Advantages claimed for the instruments are better illumination of the

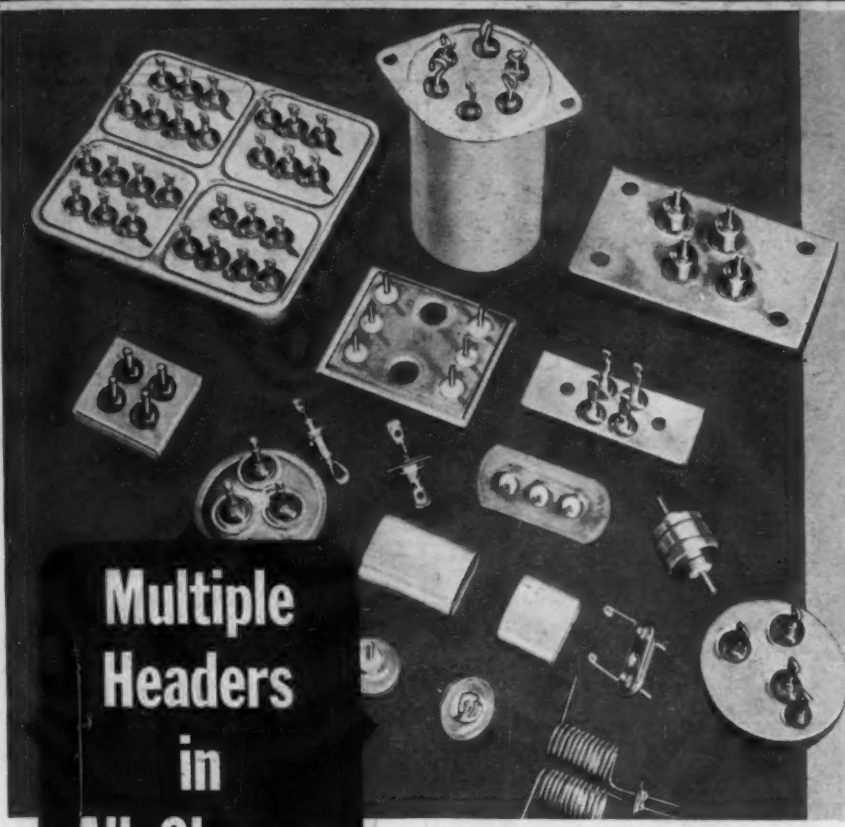



dial and an unbreakable front cover. The scale can be illuminated by conduction of light from the rear along the edge of the plastic.

## Antenna Arrays (48)

TECHNICAL APPLIANCE CORP., 41-06 DeLong St., Flushing, N. Y. The

# A Major Development in Hermetic Sealing!



## Hermico-Glass Multiple Headers and Seals in Unlimited Shapes for Unrestricted Use at 75% Material Cost Savings

## Multiple Headers in All Shapes

## .... in a COMBINATION OF NEW METAL AND GLASS FOR HERMETIC SEALING with matched coefficient of expansion

By their exclusive method of production, *HERMETIC* can provide an unlimited variety of shapes in multiple headers, with as many terminals as desired molded into a cover unit. No matter what your specifications are for shape, size and weight, single terminals or multiple headers, your requirements can be taken care of at once . . . samples within 48 hours . . . production runs, either long or short, immediately thereafter. *Hermico-Glass Headers are unhampered by any restrictions whatsoever in their use.*

Hermico-Glass Headers are vacuum-tight . . . have resistance of over 10,000 megohms between body and terminals or between terminals . . . have a permanent chemical bond between metal and glass . . . are capable of withstanding shock of hot tin dipping to facilitate soldering.

Terminals may be arranged with a minimum spacing in any pattern or combination of voltage ratings. Illustrated are only a few variations. The range is unlimited, offering you the kind of latitude that will enable you to distinguish your products from those of competition.

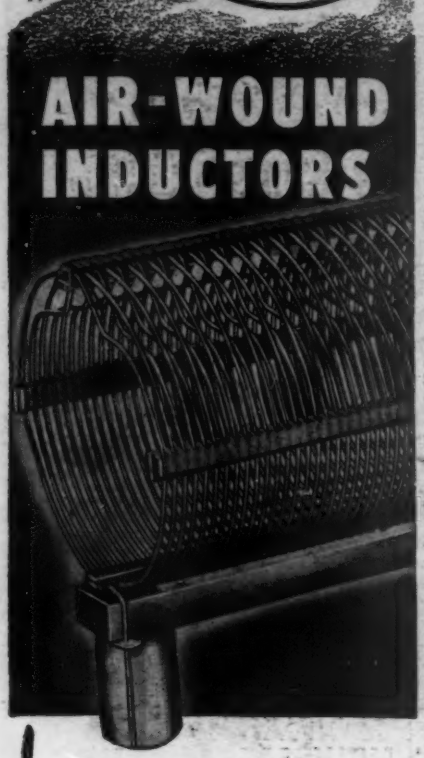
**Submit details of your requirements for samples and estimates of amazingly low cost multiple headers that are guaranteed impervious to every element. Your inquiry will receive immediate attention.**

SEALED IN by HERMETIC HEADERS

## HERMETIC SEAL PRODUCTS COMPANY

414-418 MORRIS AVENUE • NEWARK 3, NEW JERSEY

Specify B&W



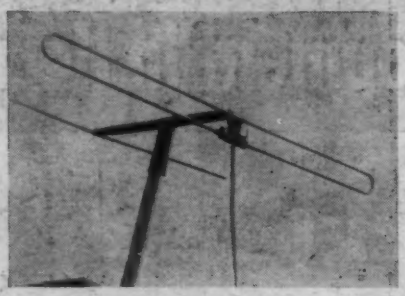

for
- LOWER DIELECTRIC LOSS
- GREATER ADAPTABILITY IN MOUNTING
- LIGHTER WEIGHT
- EASIER TAPPING
- LESS CHANCE OF BREAKAGE

All types, shapes and sizes including turrets for modern Radio-Electronic needs.

BARKER & WILLIAMSON

DEPT. E-27 237 FAIRFIELD AVE., UPPER DARBY, PA.



type 620 combination folded dipole and reflector antenna for f-m reception is illustrated. Dipole and reflector rods are aluminum, but the mast is wood to permit attaching the 300-ohm ribbon type transmission line directly to it for mechanical support. Other types of f-m, television, and a-m arrays are described in catalog 27A.

### Null Detector (49)

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. The type 707-A cathode-ray null detector is not new, but has only recently been put back into produc-

tion. It is useful at power-line and audio frequencies and can be used for the comparison of frequencies by means of Lissajous figures. Indication is by means of a one-inch cathode-ray tube.

## Literature

(50)

**Audio Amplifier.** Brook Electronics, Inc., Box 430, Elizabeth, N. J. A high quality audio amplifier with optional bass and treble controls is described in a four-page leaflet. The equipment is suitable for broadcast station or home use.

(51)

**Electrical Insulation.** James G. Biddle Co., 1211 Arch St., Philadelphia 7, Pa. Technical publica-


Soundcraft and QUALITY CONTROL

The Soundcraft name symbolizes quality control in the manufacture of recording discs. It is the recordists guarantee that every Soundcraft disc offers an identical potential for the utmost in high fidelity reproduction.

One factor in the success of Soundcraft's exacting quality control is the disc prover. Capable of measuring minute differences in surface noise, frequency response, distortion, playback life, and thread behavior, this multi-channel test set also makes and compares recordings made under typical studio conditions.

Soundcraft discs need not be stamped with serial numbers. Disc prover quality-control plus triple inspection insures that every disc is up to the Soundcraft high quality standard.

'Broadcaster' 8" 10" 12" 16"
'Audition' 6½" 8" 10" 12" 16"
'Playback' 6½" 8" 10" 12" 16"
'Maestro' 12" 13¼" 17¼"

Soundcraft

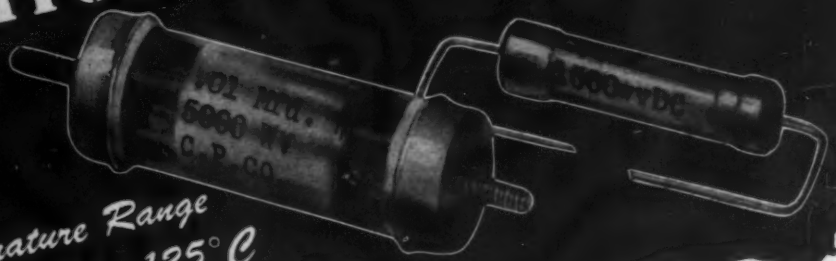
*A Disc for Every Application*

REEVES SOUNDCRAFT CORP.
10 EAST 52 ST., NEW YORK 22, N. Y.
PROGRESS ALONG SOUND LINES

# PLASTICON* ASG Silicone-Filled GLASSMIKES

# FOR HIGHER VOLTAGES

1-3/8 x 3-1/2




*Extreme Temperature Range from Minus 60° C to Plus 125° C*

*From 600 to over 30,000 Volts*

*Modern functionally designed capacitors. Metal ferrules are soldered to silver bands fused to each end of heavy-walled glass tubes. This vacuum tight assembly is fungus-proof and passes Signal Corps, Air Corps and Navy thermal cycle and immersion tests.*

***Announcing an illustrated technical booklet on uses of***

## *PLASTICON* GLASSMIKES*

***Contains the following subjects:—***

- Glassmike characteristics and design data
- Comparison of Glassmike and Mica Capacitors
- Uses of Glassmikes for improved RF and Audio bypassing
- Use in Audio and RF coupling
- Glassmike in television power supplies
- Video coupling
- Vibrator buffer applications
- Geiger Counter Capacitors
- Instrument capacitors
- And many other applications

*Come in and visit our exhibit at the I.R.E. show, March 3-7, incl.*

*WRITE for above free booklet on your firm letterhead.*

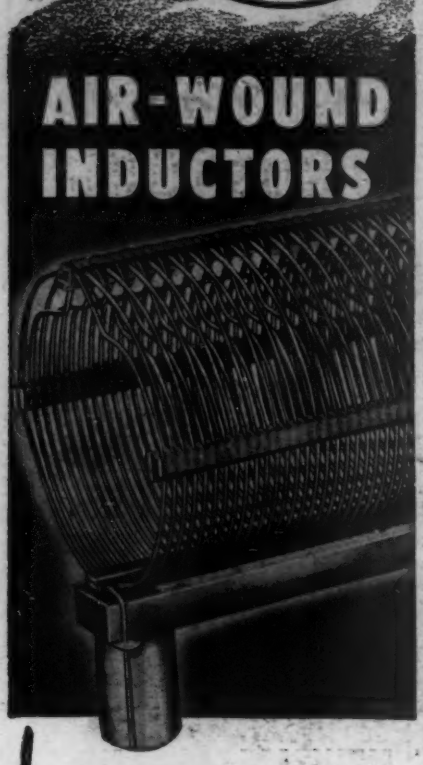
* PLASTICONS: Plastic-Film Dielectric Capacitors

**Order from your jobber: if he cannot supply you, order direct**

# Condenser Products Company

1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS

Specify B&W



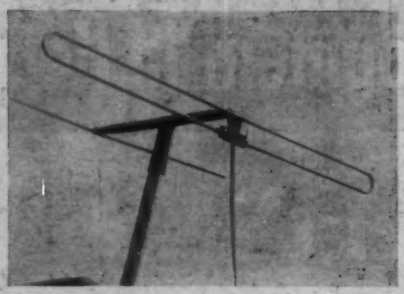

for
- LOWER DIELECTRIC LOSS
- GREATER ADAPTABILITY IN MOUNTING
- LIGHTER WEIGHT
- EASIER TAPPING
- LESS CHANCE OF BREAKAGE

All types, shapes and sizes including turrets for modern Radio-Electronic needs.

BARKER & WILLIAMSON

DEPT. E-27 237 FAIRFIELD AVE., UPPER DARBY, PA.



type 620 combination folded dipole and reflector antenna for f-m reception is illustrated. Dipole and reflector rods are aluminum, but the mast is wood to permit attaching the 300-ohm ribbon type transmission line directly to it for mechanical support. Other types of f-m, television, and a-m arrays are described in catalog 27A.

### Null Detector (49)

GENERAL RADIO CO., 275 Massachusetts Ave., Cambridge 39, Mass. The type 707-A cathode-ray null detector is not new, but has only recently been put back into produc-

tion. It is useful at power-line and audio frequencies and can be used for the comparison of frequencies by means of Lissajous figures. Indication is by means of a one-inch cathode-ray tube.

## Literature

(50)

**Audio Amplifier.** Brook Electronics, Inc., Box 430, Elizabeth, N. J. A high quality audio amplifier with optional bass and treble controls is described in a four-page leaflet. The equipment is suitable for broadcast station or home use.

(51)

**Electrical Insulation.** James G. Biddle Co., 1211 Arch St., Philadelphia 7, Pa. Technical publica-


Soundcraft and QUALITY CONTROL

The Soundcraft name symbolizes quality control in the manufacture of recording discs. It is the recordists guarantee that every Soundcraft disc offers an identical potential for the utmost in high fidelity reproduction.

One factor in the success of Soundcraft's exacting quality control is the disc prover. Capable of measuring minute differences in surface noise, frequency response, distortion, playback life, and thread behavior, this multi-channel test set also makes and compares recordings made under typical studio conditions.

Soundcraft discs need not be stamped with serial numbers. Disc prover quality-control plus triple inspection insures that every disc is up to the Soundcraft high quality standard.

'Broadcaster' 8" 10" 12" 16"
'Audition' 6½" 8" 10" 12" 16"
'Playback' 6½" 8" 10" 12" 16"
'Maestro' 12" 13¼" 17¼"

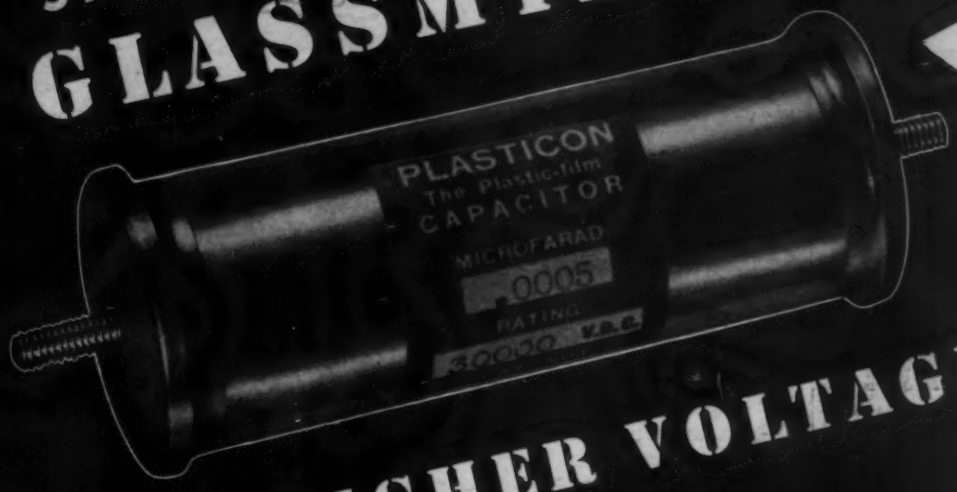
Soundcraft

*A Disc for Every Application*

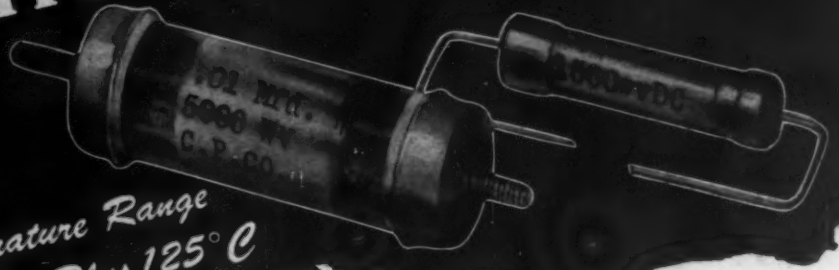
REEVES SOUNDCRAFT CORP.
10 EAST 52 ST., NEW YORK 22, N. Y.
PROGRESS ALONG SOUND LINES

# PLASTICON* ASG Silicone-Filled GLASSMIKES

1-3/8 x 3-1/2




## FOR HIGHER VOLTAGES



*Extreme Temperature Range from Minus 60° C to Plus 125° C*

**From 600 to over 30,000 Volts**

*Modern functionally designed capacitors. Metal ferrules are soldered to silver bands fused to each end of heavy-walled glass tubes. This vacuum tight assembly is fungus-proof and passes Signal Corps, Air Corps and Navy thermal cycle and immersion tests.*

***Announcing an illustrated technical booklet on uses of***

## *PLASTICON* GLASSMIKES*

***Contains the following subjects:—***

- Glassmike characteristics and design data
- Comparison of Glassmike and Mica Capacitors
- Uses of Glassmikes for improved RF and Audio bypassing
- Use in Audio and RF coupling
- Glassmike in television power supplies
- Video coupling
- Vibrator buffer applications
- Geiger Counter Capacitors
- Instrument capacitors
- And many other applications

*Come in and visit our exhibit at the I.R.E. show, March 3-7, incl.*

*WRITE for above free booklet on your firm letterhead.*

* PLASTICONS: Plastic-Film Dielectric Capacitors

**Order from your jobber: if he cannot supply you, order direct**

## Condenser Products Company

1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS

tion 21T4 entitled "Temperature-Resistance Characteristics of Electrical Insulation" summarizes the composite nature of electrical insulation and the wide variations in insulation resistance owing to temperature changes. Simplified curves of temperature correction factors are presented.

(52)
**House Organ.** Tracerlab Inc., 55 Oliver St., Boston 10, Mass. The first issue of "Tracerlog" announces its purpose to publish technical information on laboratory, medical and industrial uses of radioactivity as well as descriptions of Tracerlab products and services. The monthly publication will be mailed free to interested physicists, chemists, physicians and engineers.

(53)
**Stand-By Antenna.** Andrew Co., 363 East 75th St., Chicago 19, Ill. The type 1200 folded quadrupole antenna, approved by FCC, is immediately available for f-m transmitters. Bulletin 46 offers full details.

(54)
**Microwave Components.** Sperry Gyroscope Co., Inc., Great Neck, N. Y. A six-page folder describes a cross-section of products available. Although most of the space is given over to microwave equipment, industrial and navigation equipment is also described.

(55)
**Speech Equipment.** Collins Radio Co., Cedar Rapids, Iowa. A new catalog just published includes information on all essential speech equipment and accessories for broadcast use.

(56)
**Ceramics Wall Chart.** American Lava Corp., Chattanooga 5, Tenn. A two-color wall chart has been prepared for free distribution to engineers desiring complete information on the more widely used types of AlSiMag compositions. While the chart does not attempt to cover the many special types of

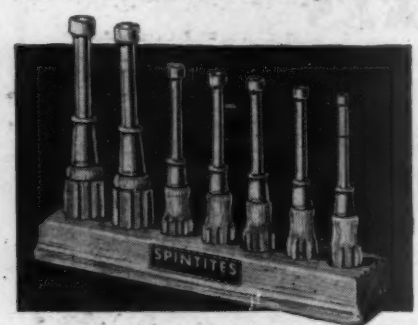
**PARTNERS IN TIME!**

Today, time saved means more than minutes—it means markets. There's no surer way to speed production than by the use of time-saving tools. That Spintite wrenches achieve this, is proved by their acceptance on the assembly lines of the radio industry.

A few simple twists of the screwdriver type Spintite speed parts into place with a minimum of waste motion.

Ranging in size from 3/16" to 5/8", Spintites are available to fit square, hex, or knurled nuts.

When time is of the essence, there's no substitute for Spintites.



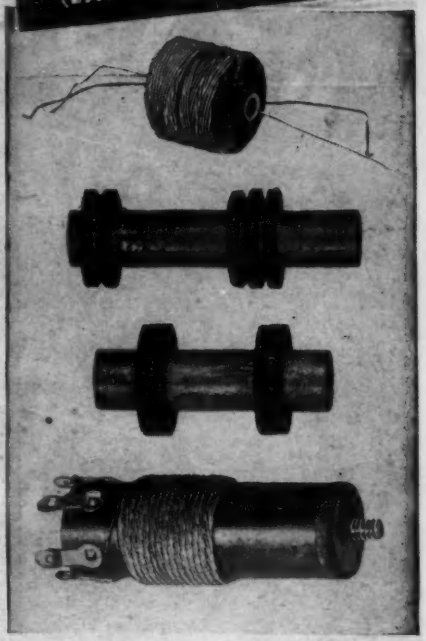

T-73 Set, has 7 sizes of hex heads. Shock-proof handles, and cold forged sockets assure safety and strength.

WALDEN WRENCHES WORCESTER

STEVENS • WALDEN
INCORPORATED
Worcester • Massachusetts



Higher Output
OF "UNIVERSAL" (LATTICE-WOUND) COILS



Up to four lattice-type coils of like specifications are produced at the same time on the No. 84 Universal Coil Winding Machine. Two machines can often be assigned to a single operator.

The higher rate of production . . . plus other advantages listed below . . . makes the No. 84 ideal for a great variety of cross-wound coils.

**ACCURACY.** Quickly-adjustable "gainer" mechanism accurately places wire turns (spaced or close-wound). "Veeder" Pre-Determining Counter.

**CONVENIENCE.** Strap-type tensions facilitate handling. In-built calibration. Quick-adjusting wire guide holders.

**PRODUCTION.** Winding speed, 400-750 rpm. Wires as fine as No. 46 unrolled without breakage.

**DURABILITY.** Many No. 84 machines now operating have been in service 20 years or longer.

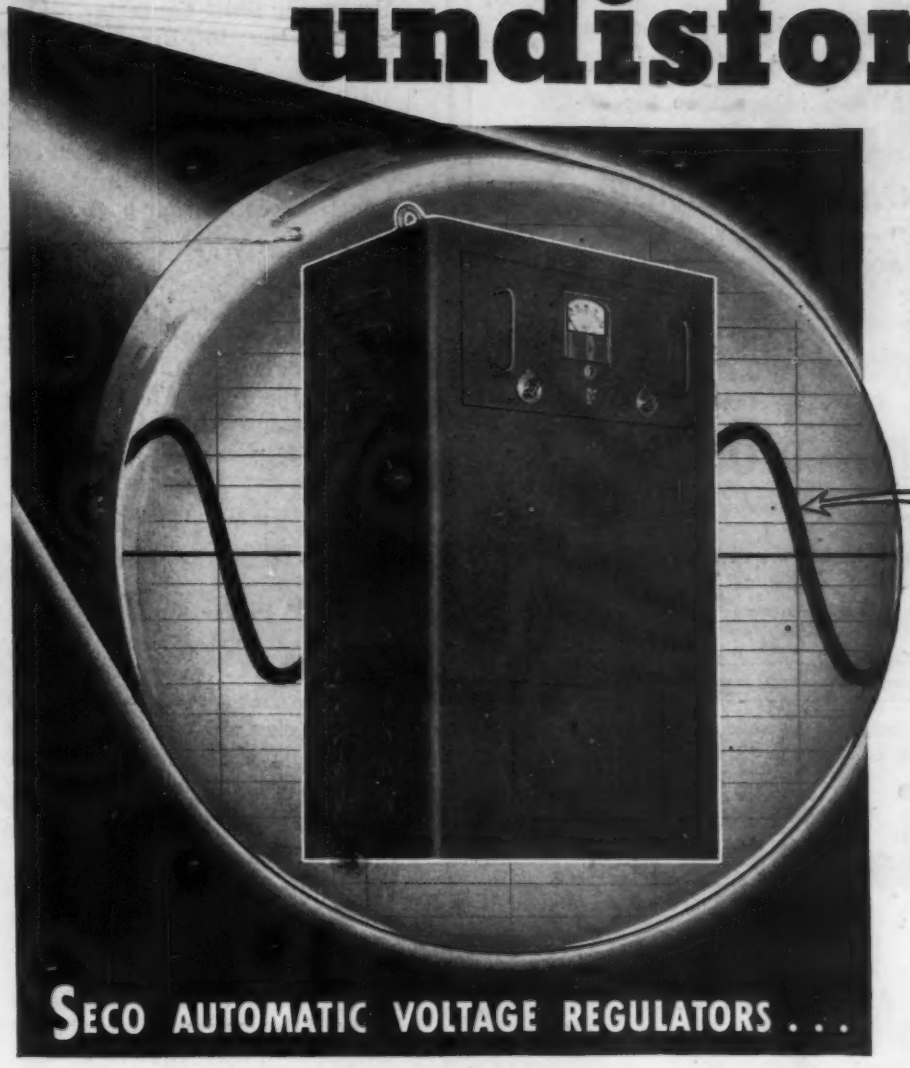
Write for Bulletin 84. Universal Winding Co., P. O. Box 1605, Providence 1, R. I.

*For Winding Coils in Quantity Automatically, Accurately—Use . . .*

23B-4-1

UNIVERSAL WINDING MACHINES

# POWER undistorted



SECO AUTOMATIC VOLTAGE REGULATORS . . .

● ZERO WAVEFORM DISTORTION...a characteristic of all SECO Automatic Voltage Regulators . . . is not the most important but certainly a highly desirable feature in voltage regulating equipment.

Please keep in mind—

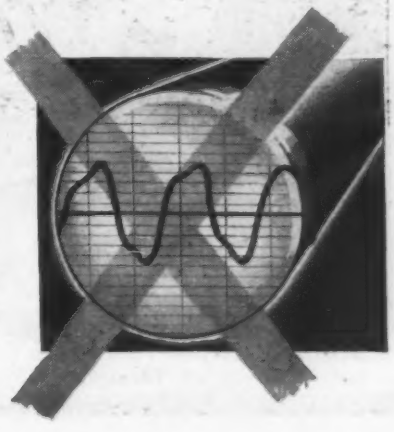
***Seco Automatic Voltage Regulators produce zero waveform distortion***

But...zero waveform distortion is just one of the many decided advantages of SECO Automatic Voltage Regulators. A few others are listed and a more comprehensive investigation would reveal such factors as low cost per KVA—easy installation—rugged mechanical construction.

Consider these combined advantages when in need of equipment to maintain CONSTANT VOLTAGE to electrical apparatus.

SECO Automatic Voltage Regulators offer more per dollar value whether the requirement involves 1 or 100 KVA.

- RAPID CORRECTION OF LINE VOLTAGE VARIATIONS
- NO CRITICAL MECHANICAL ADJUSTMENTS
- DOES NOT AFFECT POWER FACTOR of the SYSTEM
- NOT AFFECTED BY CHANGES in the POWER FACTOR OR MAGNITUDE of the LOAD



*Send for Bulletin 150 LE*

*The* **Superior** SECO **Electric** *Company*

882 LAUREL STREET • BRISTOL, CONNECTICUT, U.S.A.

*Announcement*

In order to unify the handling of all foreign business and to provide the best possible service to our customers, we are pleased to announce the appointment of:

**RCA INTERNATIONAL DIVISION**
**745 Fifth Avenue, New York 22, N. Y., U. S. A.**
**Radiogram Address: RADIOINTER**

as exclusive distributors for our product in all countries outside the United States

**BOONTON RADIO Corporation**
BOONTON·N·J·U·S·A·

*Designers and Manufacturers of*
**The Q-Meter . . QX-Checker . . Signal Generators . . And Other Direct Reading Instruments**



**BURNDY**

**HYLUGS**

**BURNDY . . . New York 54, N.Y. In Canada: Canadian Line Materials, Ltd., Toronto 13. Foreign: Philips Export Corp., New York 17, N. Y.**




ceramics available, electronic, electrical and mechanical engineers will find it of great use.

(57)

**Frequency Shift Converter.** H. O. Boehme, Inc., 915 Broadway, New York, N. Y. The type 5-C frequency shift converter accepts the output of two diversity receivers, combines the signals and converts them into polar or neutral-keyed direct current. A four-page folder.

(58)

**Power Rheostats.** International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa. Bulletin E-1 covers the characteristics and specifications of the type PRT (AN 3155) power rheostats. Temperature rise curves and dimensions are clearly pictured.

(59)

**Regulated Power Supplies.** Furst Electronics, 800 W. North Ave., Chicago 22, Ill. New catalog sheets describe the models 310-A and 310-B electronically regulated power supplies. The type 310-A also provides a source of variable a-c.

(60)

**Radar Brochure.** Radiomarine Corp. of America, 75 Varick St., New York 13, N. Y. A six-page, two-color booklet has been issued to give information on the CR-101 navigation radar equipment that operates on the 3.2 centimeter band.

(61)

**Magnetic Recorder.** Magnecord, Inc., 304 West 63rd St., Chicago 21, Ill. Specifications and a complete resume of the features of the type SD-1 magnetic wire recorder are given in a four-page brochure.

(62)

**Plastics Molding Service.** G. Felsenthal and Sons, 4100 W. Grand Ave., Chicago 51, Ill. A multicolor 24-page book arranged as a file folder shows in detail the work done by the company in making plastic computers, industrial parts,

# NOW... A NEW GRAPHITE FOR ELECTRONIC TUBES

HERE is a new grade of graphite that makes possible the design of greatly improved and more economical power tubes.

This graphite, developed as a result of wartime needs, is ***stronger than ever before.*** It has ***finer grain structure.*** And it is the ***purest graphite*** ever produced for this purpose.

Sylvania Electric Products, Inc., is taking advantage of this "National" graphite in new tubes soon to be announced.

This new "National" graphite offers you many advantages. It has no melting point and does not distort at highest temperatures. It has high *thermal emissivity,* thus permitting heavy overloads of the anode and providing a welcome reserve of plate dissipation. Also it has unmatched thermal conductivity.

Write for complete details. Address National Carbon Company, Inc., Department E.

*The word "National" is a registered trade-mark of*

**NATIONAL CARBON COMPANY, INC.**

30 East 42nd Street, New York 17, N. Y.

*Unit of Union Carbide and Carbon Corporation*

UCC

*Division Sales Offices:* Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

• *"There is a design trend toward the use of graphite for some tube applications where the greatest economy is desirable and at the same time allowing greater capability of tubes both mechanically and electrically."*... H. W. Parker, of Sylvania Electric Products, Inc., in *Radio News,* October, 1946.

# More and More Users of Extruded Vinyl Tubing are STANDARDIZING on NATVAR #400

## Here's Why:-

Most users, to make sure that they get the right tubing for a particular job, run tests on the various extruded tubings available to find out whether they are suitable. For some applications, heat resistance is of primary importance. For others, it may be tensile strength, high dielectric, oil resistance, low moisture absorption, or a combination.

Before Natvar #400 was available, it was often the practice to stock several different types of special purpose tubings. This is no longer necessary. Test reports show that Natvar #400 is able to hold its own on practically every count for which a special purpose tubing might be considered.

One of the largest electrical manufacturers reports:

> This tubing has been used in radio transformer construction here at ——— for some time, and it has been found satisfactory ... A comparison of our results with those of the supplier is very favorable ... One peculiar characteristic of this material is the manner in which it behaves after immersion in hot transformer oil. A sample before immersion gave a tensile strength of 4140 psi, and after immersion a tensile strength of 6890 psi. ... The sag test which was conducted in this investigation was more severe than is usually conducted on materials of this type. Nevertheless, this tubing performed remarkably well under these conditions ... A copy of this report is being sent to the various division engineers for review.

Another large electrical manufacturer reports:

> MATERIAL TESTED: #400 Natvar Tubing, Flexible Extruded Vinyl.
>
> Effect of Heat: Like any other plastic, this material softens upon heating, but at 125° C. it does not flow or sag. It remains unaltered, except for darkening, after a week in the drying oven.
>
> Effect of Oil: In oil at 100° C., the tubing does not swell, soften, dissolve or harden. It remains unchanged except for a change in color.
>
> Effect of Compound Treatment: The tubing flatted out due to heat, but was still pliable when removed. It is satisfactory for this application.
>
> Dielectric Strength: Dielectric Puncture Tests, using a metal rod as inner electrode, and copper ribbon as outer electrode, gave the following results (tested in oil at room temperature):

| | Short Time | Step-by-Step |
|---|---|---|
| As received | 19,000 v=725 v/mil | 17,600 v=691 v/mil |
| Dried 2 days @ 125°C | 19,000 v=744 v/mil | 16,800 v=667 v/mil |
| Dried 3 days @ 125°C plus 24 d. in oil :-100°C | 26,000 v=1023 v/mil | 19,400 v=723 v/mil |

Underwriters' Laboratories limitations permit wide use. Natvar #400 is now available for immediate shipment in most sizes, either from your wholesaler's stock or from our own. Write, wire or phone us your requirements.

**Excerpts from the E.T.L. report covering tests made on Natvar No. 400 in accordance with A.S.T.M. Standards.**

**DIELECTRIC STRENGTH—A.S.T.M. D350-43**
Average volts per mil: At 28°C—1090
At 85°C— 700
Wall thickness: .0235"

**DIELECTRIC CONSTANT AND POWER FACTOR**
Dielectric constant at 29°C and relative humidity 60%
At 60 cycles: 8.15
At 1 megacycle: 4.35
Power Factor: At 60 cycles: .056
At 1 megacycle: .064

**ARC RESISTANCE—A.S.T.M. D495-42**
Average—135 seconds

**OIL RESISTANCE—A.S.T.M. D295-43T**
"Turbol 10" at 105°C was used. After 15 minutes immersion there was no apparent change in the tubing. After 24 and 48 hours there was no sign of change in the tubing. Three separate tests were made.

**HEAT ENDURANCE—A.S.T.M. D350-43**
After 7 days at 125°C the tubing did not crack or otherwise fail when bent 180° around a 5/16" mandrel.

**TENSILE STRENGTH AND ELONGATION**
At 200% elongation: Average 1980 lbs. per sq. in.
At Maximum: Average 2870 lbs. per sq. in.
Total elongation: 350%

**LOW TEMPERATURE FLEXIBILITY**
After 3 hrs. at minus 30°F specimens were bent around a mandrel 5/16" in diameter. There was no sign of cracking or other failure.

**FLAME RESISTANCE—D350-43**
Burned about ¼ in. in 10 to 15 seconds and then went out. Three tests were made.

**EFFECT OF CHEMICALS**
Effect of 7 days immersion in solvents at room temperature; average of 3 tests in each solvent:

| Solvent | Change in weight Per cent of weight of specimen as received | Change in dimensions Per cent of dimensions of specimen as received Length | Outside diameter | Thickness |
|---|---|---|---|---|
| 5 per cent sulfuric acid | + 0.41 | none | none | none |
| 1 per cent potassium hydroxide | + 0.83 | none | none | none |
| Petroleum | + 6.62 | +2.6 | none | none |
| Ethyl Alcohol | + 1.66 | none | none | none |
| Benzol | +21.9 | +6.6 | +10.9 | —24.0 |

**WATER ABSORPTION**
Average of 5 tests
Water absorption, per cent by weight of dry specimen 0.63
Soluble matter, per cent by weight of dry specimen 0.01
Total water absorption, per cent by weight of dry specimen 0.64
Change in dimensions: in length none
in outside diameter none
in thickness none


THE NATIONAL VARNISHED PRODUCTS Corporation

TELEPHONE RAHWAY 7-2171

CABLE ADDRESS NATVAR: RAHWAY, N. J.

201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

2—NVP-1

In amateur radio today perfection is an absolute necessity. The old days of hit-or-miss operation are gone forever. A good example of the need for perfection is the ever-present menace of the PINK TICKET. Today with frequency multipliers in practically all transmitters, it is easy to hit the wrong Harmonic. The positive way to tell which band you are on, is by using the BUD WM-78 wavemeter.

The BUD WM-78 covers all amateur bands from 160 to 5 meters . . . accomplishing this by bandswitching. Due to its sensitivity the BUD WM-78 can also be used as a neutralizing indicator.

**$8.25**

your cost at your radio parts dealer

LET BUD SUPPLY
ALL YOUR NEEDS

with the latest types of radio equipment, including variable condensers, coils, chokes, dials, switches and a complete line of sheet-metalware.

BUD
BUD RADIO, INC.
CLEVELAND 3, OHIO




nameplates, scales and crystals. Tables showing characteristics of some plastics, decimal equivalents and a temperature conversion table are included.

(63)

**Flexible Shaft Index.** S. S. White Dental Mfg. Co., 10 E. 40th St., New York 16, N. Y. An index has been prepared and is available for those owning a flexible-shaft handbook.

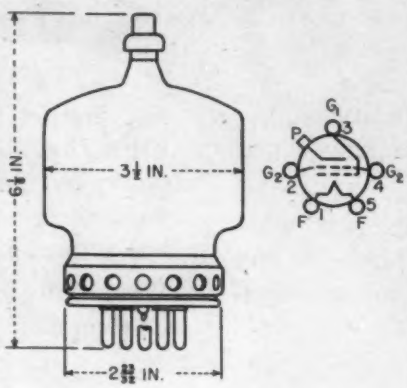
(64)

**Wire Stripper.** The Williams Products Co., 515 Main St., Middletown, Conn. A machine that cuts, strips and slits covered wire at high speed can be adjusted to any wire up to ½ inch diameter. It has been designed for production use. Further information is available from the manufacturer.

## Tube Registry

**Tube Types Registered by RMA (Starting Oct. 1946)**

### Type 5D22




| | |
|---|---|
| $E_f$ = 5.0 v | $W_p$ = 250 watts |
| $I_f$ = 14.5 amp | $C_{in}$ = 12.7 μμf |
| $E_b$ = 1,000 v (max) | $C_{out}$ = 4.5 μμf |
| $I_b$ = 350 ma | $gC_p$ = 0.06 μμf |
| $g_m$ = 4,000 μmhos | |

Tetrode power amplifier/oscillator, filament type.

### Type 6BL6

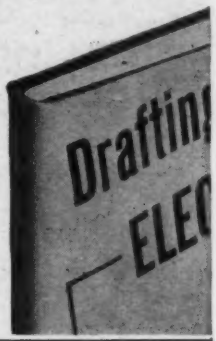
Velocity modulation reflex oscillator, heater type, pee-wee 4-pin base, metal glass envelope, maximum


*This new guide brings you the*

**special drafting know-how**

*you need to succeed in* **ELECTRONICS**

YOU can speed up your advancement considerably in electronics work with a better knowledge of diagrammatic drawing as it applies to the recent technical developments in this field. To assist you in this achievement here is a practical and up-to-the-minute drafting guidebook, written particularly for all in radio, television, industrial electronics, and communications engineering. It brings you the information you need for a clear understanding of principles and procedures which are fundamental to today's best practices in electronics drafting.




Just Out

**Drafting for ELECTRONICS**

By

**L. F. B. Carini,** Formerly United States Coast Guard Reserve, Communications Engineering Division, Coast Guard Headquarters, Washington, **211 pages, 6 x 9, 186 illustrations, $2.50.**

THIS practical guide and reference manual clearly explains and illustrates the principles of schematic development as applied to diagrammatic drafting for the electronics field. From the practical viewpoint of the draftsman it reviews drafting fundamentals and fully covers the planning, development and reproduction of specialized drawings. Based on approved standards of the American Standards Association and the Institute of Radio Engineers, the book is in accord with the most widely accepted practices. Special attention is devoted to the correct technique as applied in the projection of diagrammatic drawing and full consideration is given to progress in technical developments in electronics.

***See these 14 chapters for practical help:***

1. Schematic Drafting
2. Fundamentals of Instrumental Drawing
3. Essential of Lettering
4. Abbreviations and Letter Symbols
5. Symmetry and Balance
6. Schematic Delineation
7. Schematic Circuit Projection
8. Schematic Patent Drawing
9. Industrial Electronics
10. Technical Outline Drawings
11. Graphic Integration
12. Checking of Drawings
13. Preparing Drawing Prints
14. Drawings for Reproduction

**Examine this book 10 days free-mail coupon**

McGraw-Hill Book Co., 330 W. 42nd St., N.Y.C. 18
Send me Carini—Drafting for Electronics, for 10 days' examination on approval. In 10 days I will send $2.50, plus few cents postage, or return book postpaid. (Postage paid on cash orders.)

Name .....

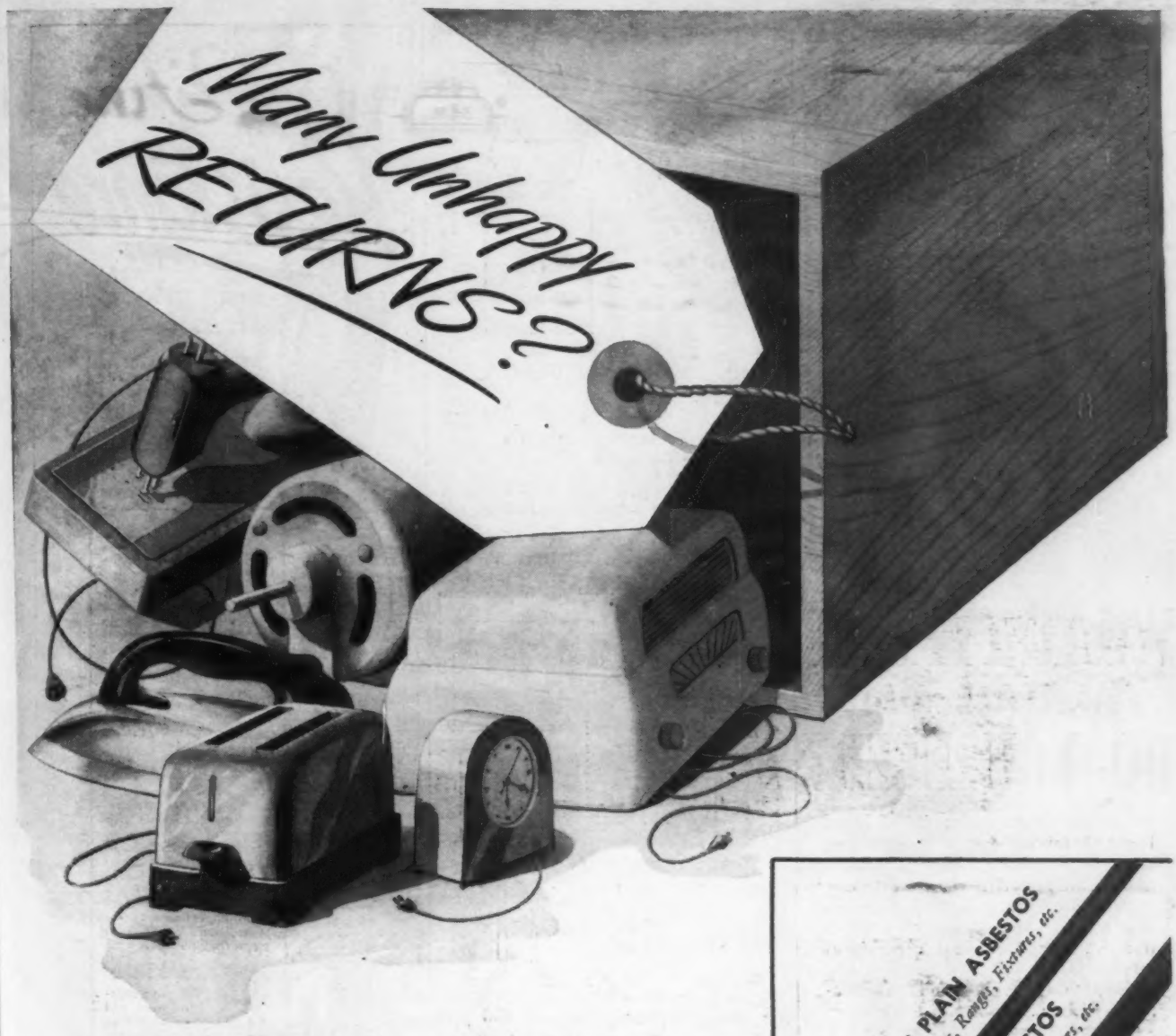
Address .....

City and State .....

Company .....

Position ..... L-2-47

For Canadian price write Embassy Book Co., 12 Richmond Street E., Toronto 1.




## *Use ROCKBESTOS Wires, Cables and Cords . to Keep Your Products in Active Service*

Makers of all sorts of products ranging from airplanes to electronic devices, who spend a lot of time and money trying to make them failure-proof, can appreciably reduce electrical failures by turning their wiring problems over to Rockbestos.

Build customer-satisfaction into your products with wires, cables and cords designed to give them wide safety margins for long-range operation under the most severe conditions. Reduce profit-eating returns for repairs or replacement and expensive service calls with Rockbestos constructions that have been time-tested under heat and moisture, oil, grease or corrosive fumes in everything from airborne radio equipment to hot metal cranes.

For information, samples, recommendations or engineering assistance write to the nearest district office or:

**ROCKBESTOS PRODUCTS CORPORATION**
**444 Nicoll St., New Haven 4, Conn.**

ROCKBESTOS PLAIN ASBESTOS
For Appliances, Radios, Ranges, Fixtures, etc.
ROCKBESTOS ALL-ASBESTOS
For Rheostats, Furnaces, Power Leads, Dryers, etc.
ROCKBESTOS A.V.C.
For Motor Leads, Power Circuits, Switchboards, etc.

*From these three basic Rockbestos constructions 125 different permanently insulated wires, cables and cords have been developed to give better service under severe or unusual operating conditions.*

# ROCKBESTOS

**The Wire with Permanent Insulation**

NEW YORK BUFFALO CLEVELAND DETROIT CHICAGO PITTSBURGH ST. LOUIS LOS ANGELES SAN FRANCISCO SEATTLE PORTLAND, ORE.

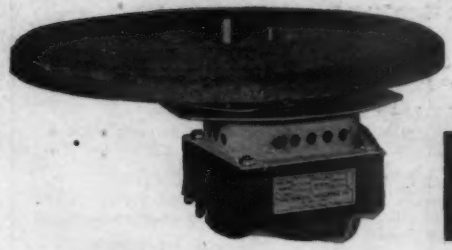
PICK-UP

..AS QUICK AS A WINK..WITH..

*Smooth Power*

Not a word or a note need be missed when your record players, record-changers or recorders are equipped with *Smooth Power* motors. That's because these units are built for split-second pick-up to full constant speed.

Their quietness and freedom from vibration give smooth performance that will delight your customers. From our complete line of *Smooth Power* phonomotors, recorders and combination record-changer recorders, you can select exactly the right units to match your own fine products.



Model GI-RM4 Smooth Power Recording Motor

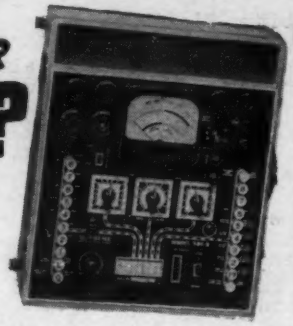
THE GENERAL INDUSTRIES CO.

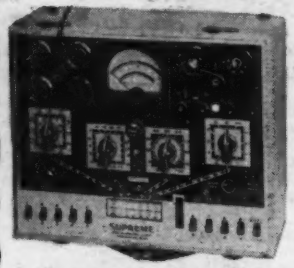
DEPT. ME • ELYRIA • OHIO



HAVE YOU RECEIVED YOUR ? SUPREME?

While our production has not yet caught up with the heavy demand for SUPREME Testers, it is steadily increasing.





If you have not received your SUREME Tube Tester, Set Tester, Oscillator, Oscilloscope, Multi-Meter, check with your Authorized SUPREME Distributor.

Big new catalogue now ready. For complete description of all SUPREME Testers, and Panel Meters, write today.

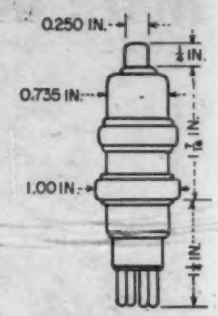
* * *

EXPORT DEPT. THE AMERICAN STEEL EXPORT CO., INC.
374 MADISON AVE., NEW YORK 17, N.Y.

SUPREME INSTRUMENTS CORP., GREENWOOD, MISS., U.S.A.




$E_h$ = 6.3 v
$I_h$ = 0.65 amp
$E_{c1}$ = 0 v
$E_{c2}$ = 325 v
$E_{b2}$ = 325 v
$I_b$ = 25 ma
Repeller = −40 v




operating frequency (3¾ mode) 2,200 mc.

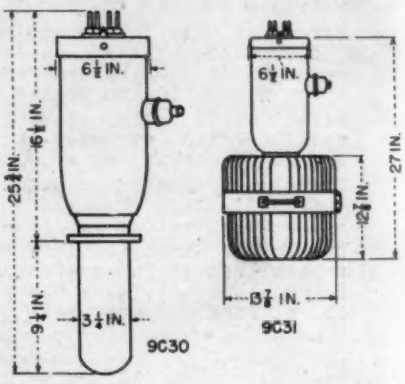
## Type 3C33

Double triode power amplifier/oscillator, heater type, integral glass envelope-base.

$E_f$ = 12.6 v
$I_f$ = 1.125 amp
$\mu$ = 11
$E_b$ = 1,000 v (max)
$I_b$ = 120 ma
$W_p$ = 15 watts
$C_{in}$ = 8.5 $\mu\mu$f
$C_{out}$ = 4.0 $\mu\mu$f
$gC_p$ = 5.2 $\mu\mu$f

## Types 9C30 and 9C31

Triode power amplifier/oscillator, filament type (9C30 water cooled, 9C31 forced air).

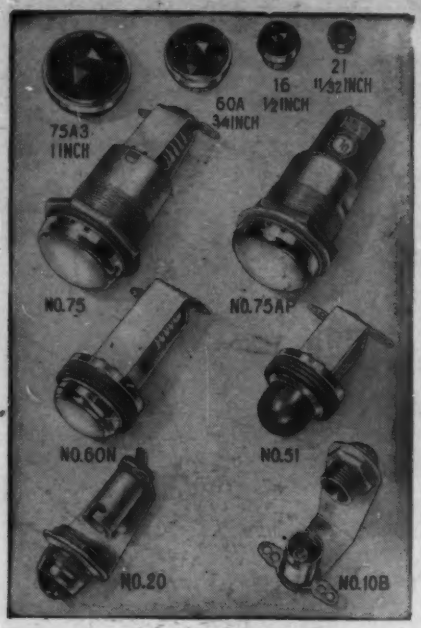



$E_f$ = 15 v
$I_f$ = 135 amp
$\mu$ = 42
$g_m$ = 14,000 $\mu$mhos
$E_b$ = 15,000 v(max)
$I_b$ = 8 amp
$E_c$ = −3,000 v
$I_c$ = 1 amp

$W_p$ = 40,000 w (9C30), 20,000 w (9C31)
$C_{in}$ = 46 $\mu\mu$f
$C_{out}$ = 5.6 $\mu\mu$f
$gC_p$ = 9C30 = 35 $\mu\mu$f
9C31 = 40 $\mu\mu$f

## Type 7C27

Triode power-amplifier/oscillator, forced air cooled, thoriated tungsten filament type, metal glass en-




# WHAT TYPE OF *Jewel Assembly* DO YOU NEED?

No matter what type or size of Jewel Light Assembly you need, chances are we can produce it for you quickly, more satisfactorily, *and at lower cost!* Here, every facility is available for high speed quantity production . . . speedy, efficient, economical service. Drake *patented features* add greatly to the value and dependability of our products.

You'll like the friendly, intelligent cooperation of our engineers. Let them help you with signals or illumination problems. Suggestions, sketches, cost estimates or asking for our newest catalog incur no obligation.

DRAKE

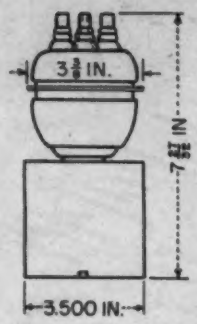
SOCKET AND JEWEL LIGHT ASSEMBLIES

DRAKE MANUFACTURING CO.

1713 W HUBBARD ST. CHICAGO 22, ILL.


NEW PRODUCTS (continued)

$E_f$ = 16.0 v
$I_f$ = 28.5 amp
$\mu$ = 27
$E_b$ = 4,000 v
$I_b$ = 2.0 amp
$E_{c1}$ = −1,000 v
$I_c$ = 0.2 amp
$W_p$ = 3,000 w
$C_{in}$ = 14 $\mu\mu$f
$C_{out}$ = 0.4 $\mu\mu$f
$gC_p$ = 14 $\mu\mu$f

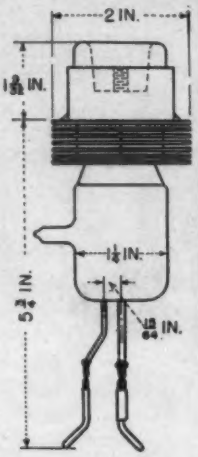



velope, maximum ratings up to 110 mc.

## Type 4C27

Triode power amplifier, forced air cooled, heater type, metal glass envelope. Typical operation at 215

$E_f$ = 6 v
$I_f$ = 6.5 amp
$\mu$ = 23
$E_b$ = 8,000 v (max)
$E_{c1}$ = 1,000 v
$W_p$ = 150 watts
$C_{in}$ = 11 $\mu\mu$f
$C_{out}$ = 2.25 $\mu\mu$f
$gC_p$ = 8 $\mu\mu$f

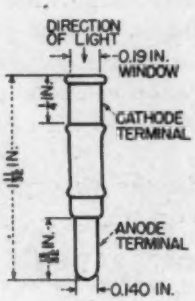



mc using 2 $\mu$sec pulses at 400 pps gives peak power output of 50,000 watts.

## Type 1P42

Phototube, high-vacuum, spectral response S-4, wavelength of maximum response 4,200 Angstrom, capacitance 1.2 $\mu\mu$f. Sensitivity at

$E_b$ = 150 v (max)
$I_b$ = 0.4 $\mu$amp (average)




maximum response, 0.020 $\mu$amp per $\mu$watt; luminous sensitivity, 25 $\mu$amp per lumen. Temperature 75 C (maximum).


*Fine* **Resistance WIRE**

**ALLOY "A"** Nickel-Chromium alloy, resists oxidation at elevated temperatures; up to 2100° F. Also used for fixed non-magnetic resistors. Resists chemical corrosion by many media. Specific resistance 650 Ohms/-C.M.F.

**ALLOY "C"** Nominally 60% Nickel, 15% Chromium, balance iron. High resistance to oxidation and corrosion. Widely used for resistors for radio, electronics, industrial equipment and domestic appliances. Operating temperatures up to 1700° F. Specific resistance 675 Ohms/C.M.F.

**ALLOY "45"** Copper-Nickel alloy with constant resistance over wide range of temperatures. Specific resistance 294 Ohms/C.M.F.; temperature coefficient 0.00002 Ohms per deg. F.; 32-212 deg. Used in winding of precision resistors, rheostats, and electrical measuring devices.

**KANTHAL** Exclusive manufacturers and distributors of KANTHAL wire, ribbon, and strip. An alloy containing Iron, Chromium, Aluminum and Cobalt . . . for operating temperatures up to 2462° F. Three grades, A-1, AS, DS; resistivity 872, 837, 812 Ohms/-C.M.F., respectively, at 68° F.

As fine as .0006" for alloys "A", "C," "45."

*and Fine Wire Screen*

**IN *TUNGSTEN* and OTHER METALS AND SPECIAL ALLOYS; ALL MESHES IN STANDARD WIDTHS, OR WIRE-MESH PARTS FABRICATED TO ORDER.**

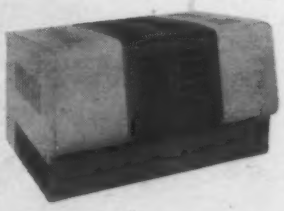
***Write for Catalogs.***

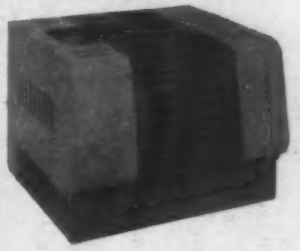
**THE C. O. JELLIFF MFG. CORP.**
**123 PEQUOT ROAD,**
**SOUTHPORT, CONNECTICUT**
**WIRE CLOTH**
**DIPPING BASKETS**
***LEKTROMESH***

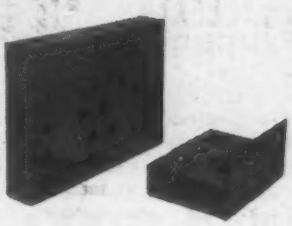
# *At Your Service*

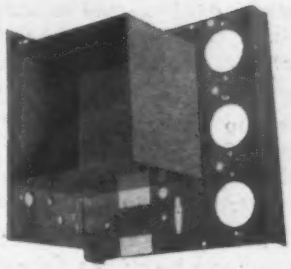
to help you with your

## SHEET METAL FABRICATION REQUIREMENTS









SHEET METAL PRODUCTS—*such as:*
INSTRUMENT PANELS, RADIO COMMUNICATION CASES and ENCLOSURES, OSCILLATOR BOXES, CHASSIS and CABINET ASSEMBLIES, RACKS and SPARE PARTS BOXES, WATERPROOF CABINETS and BOXES, METAL STAMPINGS, FORMING and WELDING of FERROUS and NON-FERROUS METALS.

We specialize in RADAR and RADIO COMMUNICATION METAL PRODUCTS. "Whistler and Wiedermann Setups" used for economic and speedy production.

We can assure you of excellent workmanship and prompt deliveries. Send us your blueprints and specifications. We shall quote you immediately.

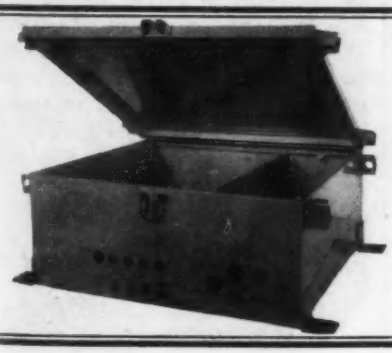
**Our additional facilities enable us to solicit your inquiries regarding SCREW MACHINE ITEMS and GENERAL MACHINE SHOP PRODUCTS.**

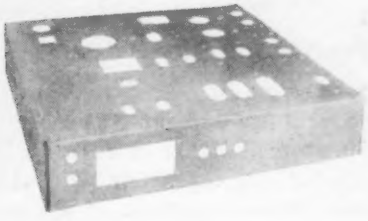
# S. WALTER CO.

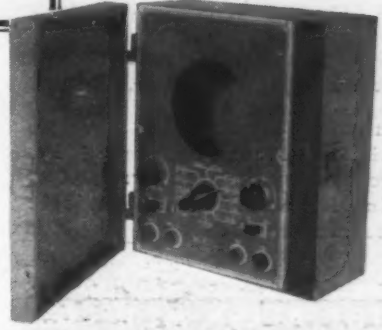
**PRECISION SHEET METAL PRODUCTS**

**144-146 CENTRE STREET BROOKLYN 31, N. Y.**

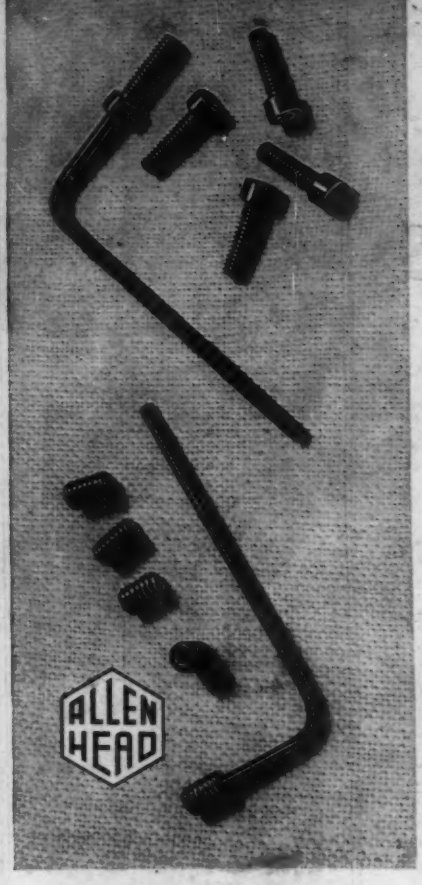
**Telephone, MAin 4-7395**







ALLEN




**Small screws for electronic devices**

Tiny hex-socket Cap Screws and Set Screws steeled to stand amazingly tight set-ups. Cap Screws in the numbered sizes from 1 to 10 inclusive; Set Screws from No. 2 to 10.

The Cap Screws are *Allen "pressur-formd"* for maximum strength of head and socket. Threads also formed by pressure-process to a high Class 3 fit.

The Set Screws have die-cut threads accurate to a high Class 3 fit, with perfectly-formed hex sockets. The screws can be held on either end of the handy hex keys and turned into the tapped hole without fingering. Allen Hand Drivers are available to facilitate fast assembling.

In radio and television sets, radio telephones, radar equipment, electronic controls, these screws *HOLD* fine adjustments and intricate assemblies.

*Order of your local Industrial Distributor*

THE ALLEN MFG. CO.,
HARTFORD 1, CONN., U. S. A.

NEWS OF THE INDUSTRY (continued from p 150)

and KOPY-FM elected as president; Everett L. Dillard is vice-president, Frank A. Gunther is secretary, Arthur Freed is treasurer, and J. N. Bailey is executive director. The temporary address of FMA is 810 International Bldg., Washington, 4, D. C. The new group was organized in Chicago during the NAB convention after a majority of the members of its predecessor, FMBI, voted to dissolve that organization.

## Latin American Television

IN MEXICO, Cuba, Puerto Rico, Brazil, and other South American countries hundreds of thousands of people are seeing themselves on television screens for the first time as a result of two television shows. The Havana show used Du Mont equipment and was sponsored by

**Waveguide and reflector of RCA microwave radio relay transmitter, set up near ring of Mexico City's 60,000-seat bullring for beaming first televised bullfights to a hotel six miles away**

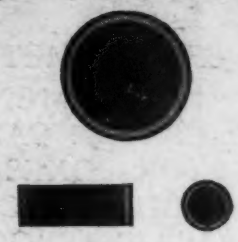
Compania Importadora de Lubricantes, S. A., which is installing a complete Du Mont-equipped television station in that city. The other show, staged by RCA, appeared first at Mexico City and is scheduled to make the rounds of Latin American cities. Both were black-and-white television.

## Production Figures

TELEVISION set manufacturers produced 1,844 sets in November to double their figure of 827 sets for October and completely outshadow September production of 19 sets, according to RMA reports. A previous RMA report of 3,242 tele-

BRADLEY

PHOTO ELECTRIC CELLS



**Unmounted Cells**

The shapes of Luxtron photocells vary from circles to squares, with every in-between shape desired. Their sizes range from very small to the largest required.

In addition to the unmounted cells shown here, Bradley also offers cells in a variety of standard mountings, including plug-in and pigtail types.

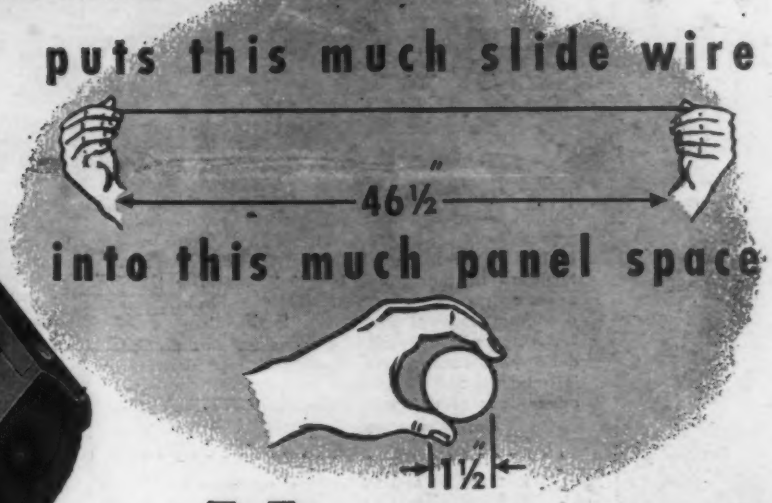
For direct conversion of light into electric energy, specify Bradley's photocells. They are rugged, lightweight and true-to-rating.

Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

BRADLEY
LABORATORIES, INC.
82 Meadow St. New Haven 10, Conn.

# This new type potentiometer-rheostat...

Cutaway View of Helipot




# It's the BECKMAN Helipot

(Trade mark for the HELical POTentiometer)

**No matter what type quality electronic instrument you may be manufacturing or preparing to manufacture, be sure to investigate the *multiple* advantages you can build into your product by using Beckman Helipots for resistance control. War-perfected on such ultra-precision electronic equipment as radar, flight control instruments, depth sounding devices, etc., the Beckman Helipot makes possible entirely new standards of accuracy, convenience and compactness in resistance controls.**

Unlike conventional potentiometers which consist of a single turn of slide wire, the Helipot has *many* turns of slide wire *helically* coiled into a compact case *that occupies no more panel space than a conventional single-turn potentiometer.* The slider contact is rotated by a knob in the usual manner and a simple device guides the slider contact as the knob is rotated so that the entire helical length of resistance winding can be contacted.

**Its advantages are many.** Heretofore circuits requiring precise control coupled with wide range have generally required at least two potentiometer units—one for coarse adjustment and the other for fine adjustment. This means *two* knobs to operate... *two* controls to waste panel space... *two* units to complicate installation and wiring. In the Beckman Helipot *both* wide range and fine adjustment are combined in the one unit. There is only one knob to operate... one unit to take up panel space... one control to install and wire. You not only save valuable panel space and assembly time, but you greatly increase the convenience, utility, simplicity and operating efficiency of your electronic instruments. Note these outstanding Helipot features...

***High Linearity***—As a result of fulfilling wartime requirements for ultra-precision circuit controls, Helipots are mass-produced with linearity tolerances of *one tenth of one per cent*—and even less!

***Precise Settings***—Because of the many times longer slide wire, settings can be made with an accuracy impossible with single turn units.

***Wide Range***—By coiling a long potentiometer slide wire into a helix, the Helipot provides *many times* the range possible with a single turn unit of comparable diameter and panel space.

***Low Torque***—Of special interest for power-driven applications—the Helipot has unusually low torque characteristics. The 1½" Helipot—for example—has a torque of *only one inch/ounce.*

## Helipots are Available in 3 Standard Sizes

**TYPE A** — 5 watts, incorporating 10 helical turns and a slide wire length of 46½", coil diameter 1½", is available with resistance values from 25 ohms to 30,000 ohms.

**TYPE B** — 10 watts, with 15 helical turns and 140" slide wire, coil diameter 3", is available with resistance values from 100 ohms to 100,000 ohms.

**TYPE C** — 2 watts, with 3 helical turns and 13½" slide wire, coil diameter 1½", available in resistances from 5 ohms to 10,000 ohms.

The Type B is also available in special sizes of 25 and 40 helical turns, with resistances ranging from 500 ohms to 300,000 ohms, and containing more than 100,000 change of resistance steps.

*Data in heading are for the standard Type A unit.*

**SEND US YOUR POTENTIOMETER PROBLEM and our engineering staff will be glad to work with you in applying Helipot advantages to increase the efficiency, accuracy and convenience of your quality electronic instruments.**

**THE HELIPOT CORPORATION, 1011 MISSION STREET, SOUTH PASADENA 2, CALIFORNIA**

# IN·RES·CO RESISTORS

## Close tolerance units for precision performance

IN-RES-CO resistors are engineered to meet all important electronic application needs.* They are wire wound for permanent, exact resistance value and both inductive and non-inductive types are standard. Standard tolerances are 1 and 2%—closer tolerances on special order. Rigid quality control assures a uniform standard of excellence and modern manufacturing facilities result in low unit cost and prompt delivery. Manufacturers of electrical and electronic instruments and equipment should investigate the advantages of designating IN-RES-CO as their exclusive wire wound resistor source.

TYPES RN AND SN Trepi-pruf resistors—RN: 3/4" long x 5/8" dia., Max. Res. 1/2 Megohm, 1/2 watt; SN: 1-3/16" long x 5/8" dia., Max. Res. 1 Megohm, 1 watt

IN-RES-CO

INSTRUMENT RESISTORS CO.

1036 COMMERCE AVE. UNION, N. J.



FIBRE FABRICATION TECHNICAL DATA FREE

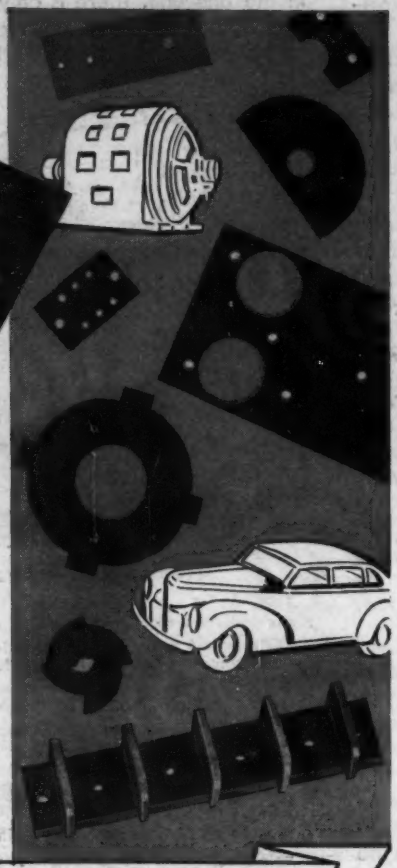
WRITE FOR BULLETIN 120

Baer

PHENOL AND VULCANIZED

FIBRE

FABRICATIONS FOR INDUSTRY



*Design short-cuts*- cutting engineering and assembling time

Time saved in preliminary planning is directly proportionate to efficiencies effected in the blueprint stage. By designing-in BAER fibre fabrications—whether your product is instrument, machine, appliance or equipment—the utmost in production stream-lining is assured. Further, the inherent advantages of the material—accurately machined, stamped, punched, drilled, milled or sawed by BAER craftsmen—adds a full measure of dependability under varying service conditions.

N. S. BAER COMPANY, 9-11 MONTGOMERY ST., HILLSIDE, N. J.




vision sets for September was in error, according to RMA, because one manufacturer had listed 3,223 phonographs in the television column by mistake.

Total for all sets by RMA companies in November was 1,496,482, of which a new high of 27,330 had f-m bands. The decrease over October is due to fewer working days.

•

## New Synchro-Cyclotron

A NEW electron accelerator with magnet poles 110 inches in diameter is in the planning stage at Carnegie Institute of Technology, Pittsburgh, as a result of a grant of $300,000 for this purpose by The Buhl Foundation. The machine will be exceeded in size among existing machines only by the giant 184-inch cyclotron at the Radiation Laboratory of the University of California. The grant is conditioned upon at least $250,000 being subscribed by others for the same purpose.

## 1947 Broadcast Engineering Conference is Cancelled

PLANS FOR holding the 1947 Broadcast Engineering Conference, sponsored annually by the Departments of Electrical Engineering at the University of Illinois and Ohio State University, have been cancelled due to crowded conditions and lack of sufficient personnel at both universities. The 1947 conference originally was scheduled to be held at the University of Illinois. Some 400 persons attended the sixth annual conference last March 18-23 at Ohio State.

## Spectroscopic Research

THE SPECTROSCOPY Laboratory of MIT, devoted during the war almost entirely to work for the Manhattan District, will now operate as an independent entity under the office of the Dean of Science to make its facilities more directly available to research workers in all principal fields of spectroscopy. Specific research programs are

planned in fields of wavelength and intensity measurements, ultraviolet, visible, and infrared absorption spectrophotometry, and the Raman and Zeeman effects.

## Three-Tube Sets for India

PRODUCTION is now under way in Bombay, India on a three-tube pretuned radio receiver that costs about $45 to produce and is selling for the equivalent of $28.50. Costs are expected to drop to $19.50 as output goes up, however. Estimated demand is 1,000,000 sets even under present conditions.

Of the approximately 40 components employed, only tubes, loudspeaker, and volume control are imported. Tubes come from the United States and cost 35¢ each, as contrasted to a quotation of 72¢ by Philips of Eindhoven. The cabinet is solid teak.

Fixed-price merchandising is in effect, with a ten-percent gross margin for the distributor. If dealers prove cool to the proposition, the manufacturer, National Radio & Engineering Co., Ltd., plans to set up retail merchandising facilities. The cheapest imported set in India now costs about $75 and does not always meet domestic requirements.

## British Television

AFTER SEVEN YEARS of picture-free ether over Britain, the BBC has picked up television where it left off in 1939, using 405-line definition. BBC has promised manufacturers that there will be no technical improvements in the next three years that might make present receivers obsolete.

### *MEETINGS TO COME*

JAN. 27-31; ELECTRICAL ENGINEERING EXPOSITION held concurrently with AIEE winter convention; 71st Regiment Armory, New York City.

FEB. 13-14; INSTITUTE OF NAVIGATION; Eastern Regional Meeting; Hotel Pennsylvania; technical pa-


Just Out!

CONCORD
Bargain Catalog of
RADIO
Equipment
FOR
Immediate Shipment

Just off the press—48 exciting pages of radio parts, equipment, and supplies for dealers, servicemen, amateurs, maintenance, testing, building and experimenting—Thousands of items NOW IN STOCK and ready for IMMEDIATE SHIPMENT! Big feature sections of Radio Sets, Communication Receivers, Amplifiers, Ham Gear, Record Players and Portables, Record Changers and complete Sound Systems. Page after page of bargains and special values in top-quality standard-make radio and electronic parts.

**Mail Coupon NOW for FREE COPY**

Mail coupon below TODAY for your FREE COPY of this latest Concord Buying Guide and Bargain Catalog of Radio and Electronic needs you can order for SAME DAY SHIPMENT from complete stocks in Chicago and Atlanta.

CONCORD
RADIO CORPORATION
LAFAYETTE RADIO CORPORATION
CHICAGO 7, ILL. 901 W. Jackson Blvd.
ATLANTA 3, GA. 265 Peachtree St.

CONCORD RADIO CORP., Dept. G-27
901 W. Jackson Blvd., Chicago 7, Ill.
Yes, rush FREE COPY of the new Concord Bargain Catalog.
Name.....
Address.....State.....
City.....

## for Delicate Soldering Tasks

# VULCAN

# Pygmy

## ELECTRIC SOLDERING TOOLS

Finds its way in where there is little clearance or cramped space.

Particularly useful for meters, electrical instruments, small radios and similar articles.

UL

STANDARD ¼ INCH
Also Available 3/16 Inch

**VULCAN ELECTRIC COMPANY**
DANVERS, 10, MASS.

• Makers of a wide variety of Heating Elements for assembly into manufacturer's own products and of Heating Specialities that use electricity.

PREMAX

# RADIO ANTENNA

## FOR MOBILE UNITS

High-tempered steel Antennas and specially designed mountings that will meet every need for mobile installations in police, fire and other municipal and governmental services. Get the new Premax Antenna Catalog from your radio jobber.

Premax Products

**Division Chisholm-Ryder Co., Inc.**
4711 Highland Ave. Niagara Falls, N. Y.

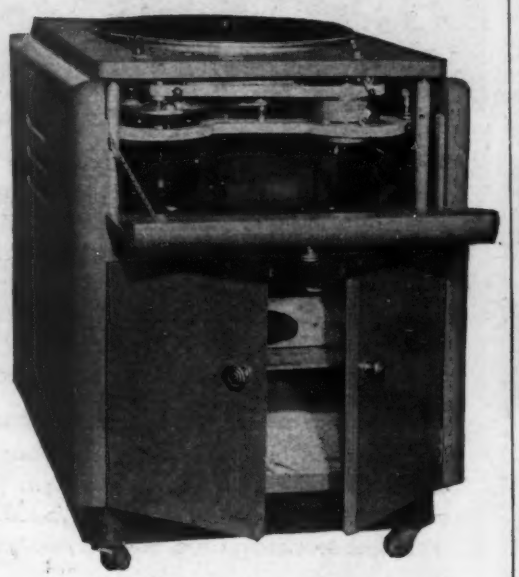
## Robinson "PRECISION" Turntables Now Available

★ No "Wow" or vibration whether it's Brahms, boogie or voice.

★ "Right angle" belt drive and patented "seismic" sub base motor mounting.

★ Instant, foolproof lever shift from 78 to 33⅓ R.P.M.

★ New micrometer speed adjustment and patented planetary ball bearing transmission.



*Console $90 · Chassis $295*
*Duplex Console $150*

**ROBINSON RECORDING LABORATORIES**
35 SO. NINTH ST., PHILADELPHIA 7, PA.

*for dimensional accuracy!*

**METAL STAMPINGS**

**DKE**

DKE stamped metal parts can now be supplied in any quantity on short notice. Twenty years experience in producing all types of cups, sleeves, flanged shapes, and fabrications to specification. Tools, jigs, fixtures produced on premises for precision and economy.

INQUIRIES INVITED

**THE ENGINEERING CO.**
DANIEL KONDAKJIAN
27 WRIGHT ST., NEWARK, N. J.

pers; Paul Rosenberg, chairman, Woolworth Bldg., New York 7.

FEB. 20-22; OPTICAL SOCIETY OF AMERICA; Winter Meeting; Hotel Pennsylvania.

MARCH 3-6; IRE WINTER MEETING; Hotel Commodore, New York City, with Radio Engineering Show at Grand Central Palace.

MARCH 22-27; WESTERN METAL CONGRESS AND EXPOSITION; Oakland Civic Auditorium, Oakland, California.

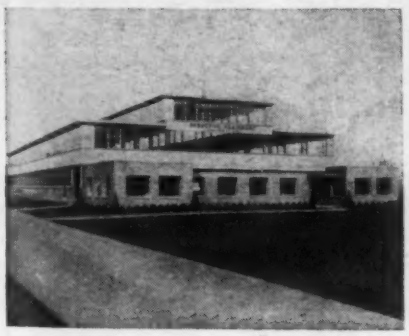
MARCH 31-APRIL 2; MIDWEST POWER CONFERENCE; Palmer House, Chicago; sponsored by Illinois Institute of Technology and directed by Prof. S. E. Winston.

MAY 13-16; 1947 CONFERENCE AND SHOW; Radio Parts and Electronic Equipment Shows, Inc., Chicago, Illinois.

## *BUSINESS NEWS*

CARBONNEAU INDUSTRIES, Grand Rapids, Michigan, plans full-scale production soon on a complete line of loudspeakers.

INDUCTIVE EQUIPMENT CORP. has moved into its new building in Gettysburg, Pa. having 50,000 square feet of space for manufacturing magnet wire, coils, trans-



New plant of Inductive Equipment Corp.

formers, rectifiers, and various types of high-frequency equipment.

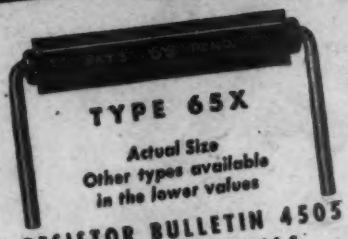
ROCKBESTOS PRODUCTS CORP., New Haven, Conn., recently added 11,000 square feet to its facilities for manufacture of permanently insulated wires, cables, and cords.

ILLINOIS CONDENSER CO., Inc. is in full operation now at its modern

Who Winds it?
that's what makes a Coil!
All the materials which go into the making of a coil may be available but more, much more is required.
There must be specialized machines and, above all, the "know-how" which comes only through engineering skill and years of experience.
The integrity of your supplier is your real assurance of dependability.
Our knowledge and modern facilities are always at your service.
COTO-COIL CO., INC.
COIL SPECIALISTS SINCE 1917
65 Pavilion Ave., Providence 5, R. I.

# S. S. White RESISTORS

## The "All-Weather" Resistors



TYPE 65X

Actual Size
Other types available in the lower values

**RESISTOR BULLETIN 4505 GIVES FULL DETAILS . . .**

It shows illustrations of the different types of S. S. White Molded Resistors and gives details about construction, dimensions, etc. A copy, with Price List will be mailed on request. Write for it—today.

- Noiseless in operation
- Strong and durable
- Good performance in all climates

**STANDARD RANGE**
**1000 ohms to 10 megohms**
**• NOISE TESTED •**

At slight additional cost, resistors in the Standard Range are supplied with each resistor noise tested to the following standard: "For the complete audio frequency range, resistor shall have less noise than corresponds to a change of resistance of 1 part in 1,000,000."

**HIGH VALUES**
**15 to 1,000,000 megohms**

**S.S.WHITE INDUSTRIAL DIVISION**
THE S. S. WHITE DENTAL MFG. CO.
DEPT. R, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED MONTURE • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

*One of America's AAAA Industrial Enterprises*



# No Spreading Ourselves Out Too Thin!

Certainly, we could expand our facilities and offer you a more complete line. But, then, we couldn't do as well on deliveries as we're now doing!

So to serve you best, we are continuing our present maximum production on a limited line—thus assuring you the usual prompt and efficient Kenyon service.

*THE MARK OF EXCELLENCE*

**KENYON TRANSFORMER CO., Inc.**
840 BARRY ST., NEW YORK, N. Y.



FOR RADIO AND ELECTRONICS
PARTS • SETS • EQUIPMENT
*ask* NEWARK *they'll have it!*

**anywhere,** you'll save time by phoning or wiring Newark Electric. Tremendous, up-to-the-minute stocks are maintained in all three stores.

**IF YOUR NEEDS** in radio or electronics parts, sets or equipment are available

★ Literature and full information on ANY manufacturer's products will be sent promptly on request. Wire or phone for quick action.

★ Our big bargain counters are loaded with new parts and unusual special equipment. Inquiring minds enjoy these displays.

**COMPETENT TECHNICAL MEN** handle your inquiries intelligently and promptly and can quote prices and delivery dates on specific merchandise. Orders shipped same day. When writing address Dept. R-5

MAIL ORDERS FILLED FROM EITHER NEW YORK OR CHICAGO.

NEW YORK 242-58 W. 55th St. New York 19, N. Y. — **NEWARK ELECTRIC COMPANY INC.** — CHICAGO 223 W. Madison St. Chicago 6, Ill.

N.Y.C. Stores: 115 W. 45th St. & 212 Fulton St. Offices & Warehouse: 242 W. 55th St. N.Y. 19

NEWARK ELECTRIC COMPANY, INC. Dept. R-5
Please send informative literature on the following:

NAME:
ADDRESS:
CITY: STATE:

P.A. Depts. in all stores. Set & Appl. Depts. in N. Y. C.

# ALLIED DISCS

and

## RECORDING EQUIPMENT

ALLIED Discs are favored by noted broadcasters and other users, for their high fidelity. Test them on your work. One of the first companies to make instantaneous recording equipment, ALLIED offers you the benefits of its seasoned skill.

*Write for our New Descriptive Bulletin.*

**ALLIED RECORDING PRODUCTS CO.**
21-09 43d Ave., LONG ISLAND CITY 1, N. Y.

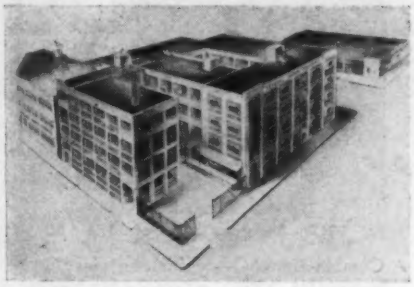
new air-conditioned single-story plant located at 1616 N. Throop St. in Chicago.

EMERSON RADIO AND PHONOGRAPH CORP., New York City, will operate Jefferson-Travis Inc. as a wholly owned subsidiary, utilizing Emerson distributing facilities for J-T marine radio equipment.

STAVER MFG. CO., Jackson Heights, New York, was formed recently by Edward F. Staver, formerly with Fred Goat Co., Inc. The new firm will manufacture electron tube parts, wire forms, clips, caps, shields, and light metal stampings.

ELECTRONIC APPARATUS, INC., New York, N. Y. has acquired a controlling interest in Tuck Electronic Corp., Jersey City, N. J., engaged in design, development, and manufacture of specialized industrial and testing electronic apparatus.

GENERAL RADIO CO., Cambridge, Mass. has started work on a new four-story addition to its main plant, to secure 30,000 square feet

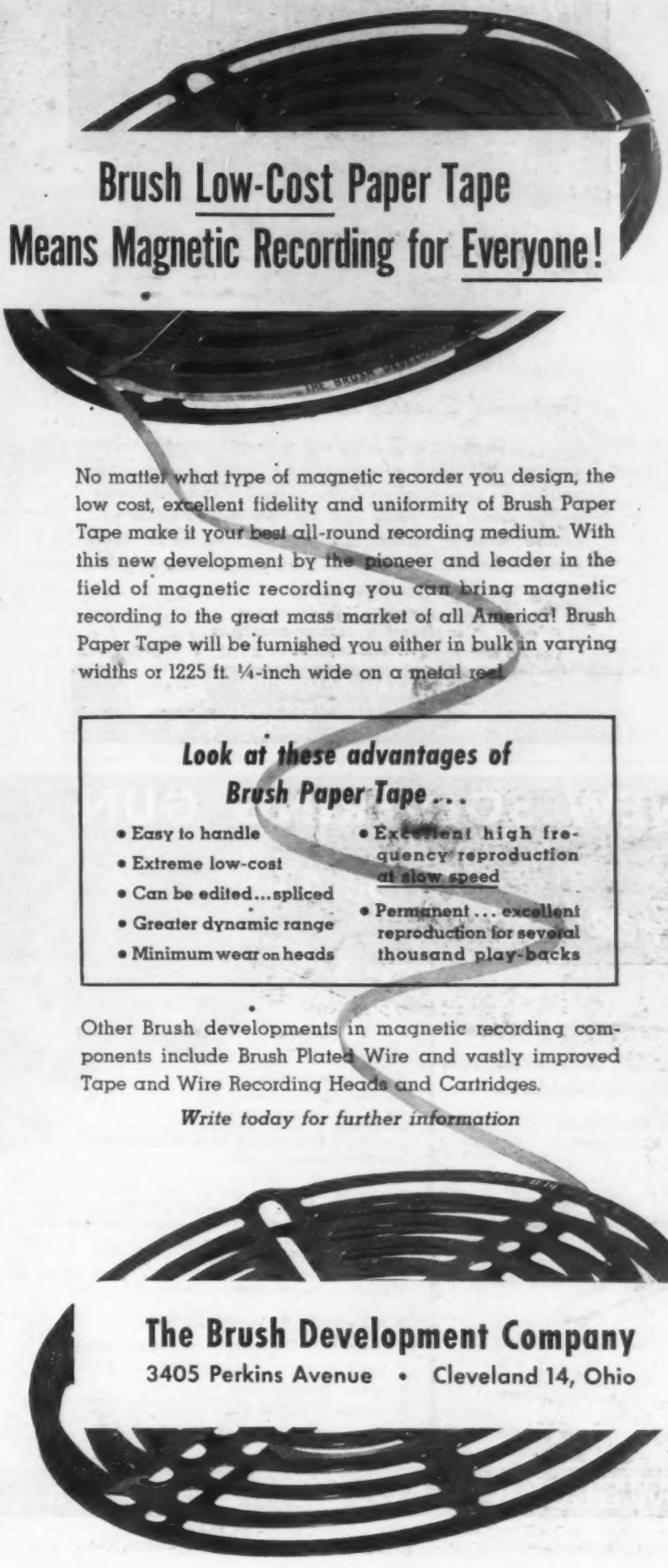


**Next spring General Radio's plant will appear like this. New addition has steps on roof**

more manufacturing space and bring the total up to 140,000 square feet.

PRESS WIRELESS MFG. CORP. announces that its engineering division is being moved from Long Island City to Hicksville, Long Island, N. Y. to expedite production.

CAPITOL RADIO ENGINEERING INSTITUTE, Washington, D. C., has had



Brush Low-Cost Paper Tape
Means Magnetic Recording for Everyone!
No matter what type of magnetic recorder you design, the low cost, excellent fidelity and uniformity of Brush Paper Tape make it your best all-round recording medium. With this new development by the pioneer and leader in the field of magnetic recording you can bring magnetic recording to the great mass market of all America! Brush Paper Tape will be furnished you either in bulk in varying widths or 1225 ft. ¼-inch wide on a metal reel
Look at these advantages of Brush Paper Tape . . .
• Easy to handle
• Extreme low-cost
• Can be edited...spliced
• Greater dynamic range
• Minimum wear on heads
• Excellent high frequency reproduction at slow speed
• Permanent . . . excellent reproduction for several thousand play-backs
Other Brush developments in magnetic recording components include Brush Plated Wire and vastly improved Tape and Wire Recording Heads and Cartridges.
Write today for further information
The Brush Development Company
3405 Perkins Avenue • Cleveland 14, Ohio

NEED SMALL BULBS and DEEP DRAWN PARTS to CLOSE TOLERANCES?

**GOAT PRECISE-FORMED DEEP-DRAWN METAL PARTS**

*Improved Quality at Lower Cost!*

Deep drawing, sizing and coining, in conjunction with quality control techniques devised by the Goat Company, make possible the economical production of small parts to tolerances unattainable a few years ago. The new method makes expensive annealing operations unnecessary. The use of these economically produced, *precision* parts reduces both material costs and assembly costs.

GOAT METAL STAMPINGS

**Send us your design prints for engineering recommendations**
Address Dept. EL

LET US REDESIGN FOR STAMPING

GOAT METAL STAMPINGS,
Division of The Fred Goat Co., Inc.
314 DEAN STREET BROOKLYN, N. Y.

# OUR STORY

is best told in person.
We'll be glad to tell
it at your convenience.

**HENRY P. SEGEL** *Company*

New in our 23d year

Electronics Manufacturers' Representatives and Field Engineers

143 Newbury St., Boston 16, Mass.
179 Kenyon St., Hartford 5, Conn.

# NEW SOLDERING GUN

*Heats in 5 Seconds*

**SPECIAL SOLDERING GUN ADVANTAGES**

TIP STAYS TINNED NO BURNING

SEE WHERE YOU SOLDER

SOLDER AROUND CORNERS

Service and maintenance men can save time by the fast heating of the Soldering Gun. By use of the new induction principle, 5 second soldering heat is supplied from a light weight built-in transformer.

The loop type tip gives you other advantages that are important in soldering. Good balance with weight close to your hand makes it easier to use. The narrow tip gets in between a lot of wiring with ease. Connections can be made without burning insulation. The tip can be formed readily to work in tight places.

See your radio parts distributor for a demonstration, or write direct for descriptive bulletin.

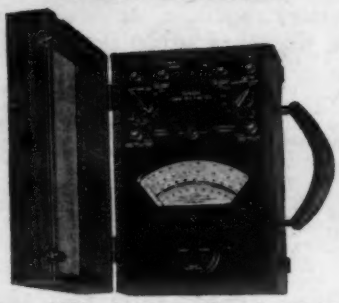
★ 100 Watts 115 Volts 60 Cycles
★ Intermittent Operation With Trigger Switch
★ Can't Overheat or Burn Out
★ Impact Resisting Case
★ Handle Stays Cool
★ Good Balance—Weight Close To Hand

806 Packer Street

**WELLER MFG. CO. · Easton, Pa.**

Export Dept.—25 Warren Street, New York 7, N. Y.
In Canada—Atlas Radio Corp., Ltd., 560 King Street N. W., Toronto, Ont.

# RAWSON TWIN MULTIMETER



Type 5012 Accuracy ½ of 1% DC
Size 12"x8"x6"
A Combination AC—Multimeter and DC Multimeter

*Range of Measurements*

DC 1 microampere to 1 Ampere.
20 Microvolts to 1000 volts.
AC (thermocouple type)
2 Milliampere to 3 Amperes.
60 Millivolts to 1000 volts.

*Write for bulletin*
*WE ALSO SUPPLY*

REGULAR DC METERS
THERMOCOUPLE AC METERS
MULTIMETERS
FLUXMETERS
ELECTROSTATIC VOLTMETERS

*Special apparatus built to order*

**RAWSON ELECTRICAL INSTRUMENT COMPANY**
111 POTTER ST. CAMBRIDGE, MASS
Representatives
CHICAGO LOS ANGELES NEW YORK CITY

both its correspondence and residence courses in radio engineering accredited by the Engineers' Council for Professional Development.

KMPC, North Hollywood, California, has enlarged its transmitter

**Artist's sketch of enlarged KMPC transmitter building. Directional antenna array at left will give equivalent of 200-kw service to greater Los Angeles**

building to incorporate a new RCA 50-F 50-kw transmitter scheduled to go on the air in January 1947.

RADIOMARINE CORPORATION OF AMERICA installed a modern marine loran receiver aboard the S. S. America while the ship was being reconditioned for peacetime service.

WOR, NEW YORK CITY, has installed an SCR-268 radar antenna on the roof of the building housing its f-m station WBAM, for experimental f-m transmissions to Washington, D. C. on 47.1 and 106.5 mc in cooperation with the Federal Communications Commission. Another version of this same antenna was used in the moon radar experiments.

FAIRCHILD CAMERA & INSTRUMENT CORP., Jamaica, N. Y. has purchased a plant in Burlington, Vermont for its new wholly-owned subsidiary company to be known as Fairchild Industries, Inc.

HOFFMAN RADIO CORP., Los Angeles, Calif. has established in what was once a car repair barn in Los Angeles its cabinet factory, involving some 76,000 sq ft of floor space.

### *PERSONNEL*

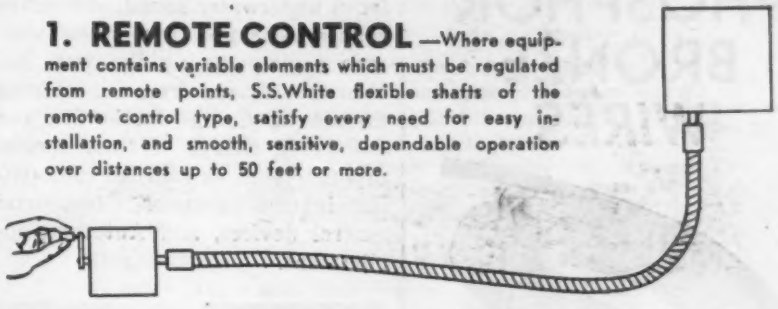
LEONARD HOLE has been named assistant director of television for CBS, and will assume many administrative responsibilities in the operation of Columbia's television station WCBS-TV in New York City. During the war he flew combat missions over France and


# 3 COMMON PROBLEMS

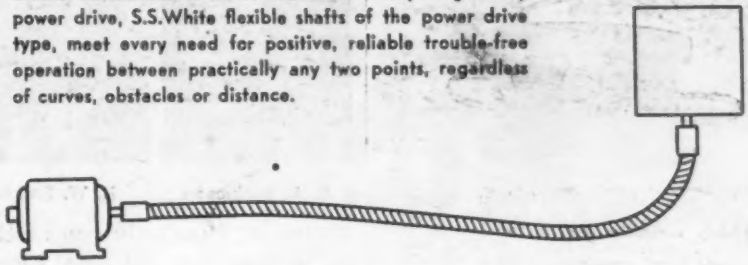
IN ELECTRONIC EQUIPMENT DESIGN

# ONE SIMPLE ANSWER

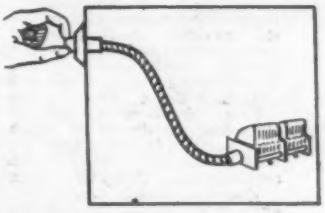
**1. REMOTE CONTROL** —Where equipment contains variable elements which must be regulated from remote points, S.S.White flexible shafts of the remote control type, satisfy every need for easy installation, and smooth, sensitive, dependable operation over distances up to 50 feet or more.



**2. POWER DRIVE** —Where equipment includes instruments or other mechanisms requiring rotary power drive, S.S.White flexible shafts of the power drive type, meet every need for positive, reliable trouble-free operation between practically any two points, regardless of curves, obstacles or distance.



**3. COUPLING** —The use of short lengths of S.S.White flexible shafting inside equipment as couplings between variable elements and their control dials, gives complete freedom in placing both the elements and the dials for space saving, easy assembly and wiring, and convenient operation and servicing.



**FOR DETAILS—WRITE FOR BULLETIN 4501**

It gives essential facts and engineering data about S.S.White flexible shafts and their application.

**S.S.WHITE INDUSTRIAL DIVISION**

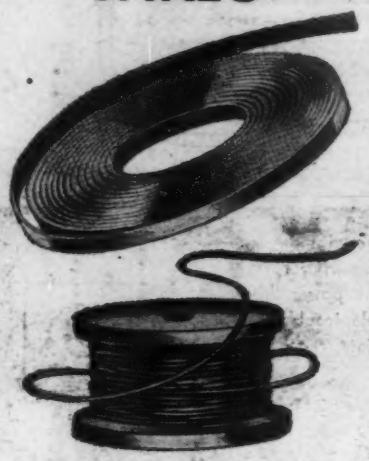
THE S. S. WHITE DENTAL MFG. CO. DEPT. E 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
MOLDED RESISTORS • PLASTIC SPECIALTIES • CONTRACT PLASTICS MOLDING

*One of America's AAAA Industrial Enterprises*

BE SURE TO
SPECIFY

PHOSPHOR
BRONZE
*WIRES*



The production of "Elephant Brand" Phosphor Bronze Wire has been *completely controlled by us* from ingot to finished size, since 1874. *It is a true bronze wire,* containing nothing but virgin copper, tin, and phosphorus. The introduction of phosphorus into this composition *reduces the oxides* and, with the purified metals, forms a most *homogeneous and uniform* alloy. These essential factors are *established scientific facts,* and have proven the superiority of "Elephant Brand" Phosphor Bronze Wire.

*This wire contains no zinc*—which eliminates the danger of season-cracking, thus has the *highest fatigue limit.* It is *made in various tempers* to meet specific requirements. "Elephant Brand" Wire is *drawn accurately to size,* is *absolutely uniform* throughout the coil, and *will not season—crack,* regardless of the time that it is carried in stock. All wire can be supplied bright-annealed. Available in the following forms:

**ROUND WIRE.** In coils for spring manufacturers
**FLAT WIRE.** In coils or lengths
**TINNED BINDING,** for armature work
**STRAIGHTENED** (Round) in lengths

**ELEPHANT BRAND PHOSPHOR BRONZE**

**THE PHOSPHOR BRONZE SMELTING CO.**
**2200 Washington Ave., Philadelphia 46, Pa.**
Original Manufacturers of Phosphor Bronze in U. S. A. . . . Established 1874


NEWS OF THE INDUSTRY (continued)

Germany using aircraft and bombs remotely controlled by radio, radar, and television.

ERNEST FREDERIK WERNER ALEXANDERSON was awarded the Valdemar Poulsen Gold Medal by the Royal Danish Academy of Science for his work in the fields of radio and television. Dr. Alexanderson, consulting engineer with General Elcetric Co., holds over 300 patents including that of the high-frequency alternator.

FREDERICK R. LACK, vice-president of Western Electric Co., will be president of the American Standards Association for 1946.

A. E. BACHMANN, civilian specialist in underwater sound, submarine countermeasures, and mine warfare devices during the war, has been transferred from engineering to sales at Collins Radio Co., and will be in charge of their special products such as railroad radio entertainment systems, industrial control devices, and Autotune applications.

A. E. Bachmann

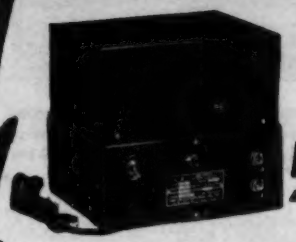
H. W. Parker

HENRY W. PARKER becomes technical adviser for Sylvania Electric Products Inc. This new post was created to stimulate review of new developments of interest to the central engineering laboratories, as well as propose new projects for research and development.

AMOS H. CAREY has been appointed director of manufacturing for John Meck Industries, Plymouth, Indiana. He was formerly in charge of manufacturing for RCA in Camden.

WALTER EVANS, vice-president in charge of all radio activities for Westinghouse Electric Corp., received the Certificate of Appreciation from the War Department for "his contribution to the Signal


*Current Conversion with* **ATR** *Quality Products*



**ATR "A"**

**BATTERY ELIMINATORS**
**FOR CONVERTING A.C. TO D.C.**
New Models . . . designed for testing D.C. electrical apparatus on regular A.C. lines. Equipped with full-wave dry disc type rectifier, assuring noiseless, interference-free operation and extreme long life and reliability.

- Eliminates Storage Batteries and Battery Chargers.
- Operates the Equipment at Maximum Efficiency at All Times.
- Fully Automatic and Fool-Proof.

**ATR**

**LOW POWER INVERTERS**
**FOR INVERTING D.C. TO A.C.**
Another New ATR Model . . . designed for operating small A.C. motors, electric razors, and a host of other small A.C. devices from D.C. voltages sources.

**ATR**

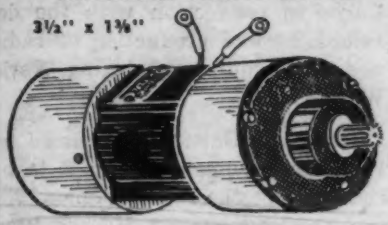
**STANDARD AND HEAVY DUTY INVERTERS**
**FOR INVERTING D.C. TO A.C.**
Specially designed for operating A.C. radios, television sets, amplifiers, address systems, and radio test equipment from D.C. voltages in vehicles, ships, trains, planes, and in D.C. districts.

**WRITE FOR NEW CATALOG—JUST OFF THE PRESS!**

**AMERICAN TELEVISION & RADIO CO**
Quality Products Since 1931
ST. PAUL 1 MINN U. S. A.

**REVERSIBLE GEARED MOTOR**

3½" x 1⅜"



Operates on Flashlight batteries, speed depending on the voltage. Fairly strong on 6 volts, full power and speed on 27 volts. Designed to be used in bombsights, automatic pilots, etc. Two types, 145 or 250 RPM. Either speed a bargain at..... **$5.00**

**BASIC MOTOR 2 X 1 X 1**

ELECTRICALLY SAME AS GEARED MOTOR **$3.00**

**ALNICO MAGNETS**

ARE AGAIN AVAILABLE
⅝ x ⅝ x ¾
SMALL HORSESHOES
2 for ..... **$1.00**

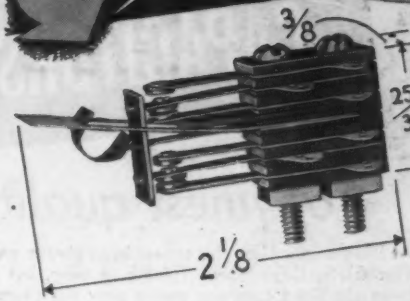
EST 1923 **BLAN** EST 1923

*Experimenters and Inventors Supplies*

**64 Dey St., New York 7, N. Y.**



**New 2 POLE Open Blade SWITCH**




Small and Compact, with Snap-Action

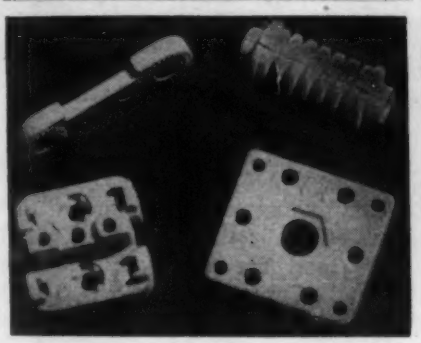
Here is the 2 pole open blade snap-action ACRO switch that many alert electrical engineers have been looking for. Built with the well known patented Rolling Spring that assures positive action. Made in both single and double throw contacts. Standard operating pressures from 3 to 5 oz. Rating: 15 Amps, 125 Volts A.C.

Movement differential—approximately 1/64" Terminals as illustrated or at rear of switch. Variations in operating characteristics are possible as well as a 3 pole design if needed to suit your application. Write for print, giving us your engineering details for quick action.

**ACRO ELECTRIC COMPANY**

**1316 SUPERIOR AVENUE · CLEVELAND 14, OHIO**





**Lavite STEATITE CERAMIC**

**Properties and Characteristics of Our LAVITE S1-5 Steatite Ceramic Body**

| | | |
|---|---|---|
| Compressive Strength | 96,000 | lbs. per square inch |
| Tensile Strength | 7,200 | lbs. per square inch |
| Flexural Strength | 10,500 | lbs. per square inch |
| Modulus of Rupture | 20,000 | lbs. per square inch |
| Dielectric Strength | 235 | volts per mil |
| Dielectric Constant | 6.42 | Frequency of 1 megacycle |
| Loss Factor | 2.90 | Frequency of 1 megacycle |
| Power Factor | 4.46 | Frequency of 1 megacycle |
| Bulk Specific Gravity | 2.664 | |
| Density (from above gravity) | 0.096 | lbs. per cubic inch |
| Hardness (Mohr scale) | 7.0 | |
| Softening Temperature | 2,350° | F. |
| Linear Coefficient of Expansion | 8.13x10⁻⁶ | |
| Moisture Absorption (ASTM D-116-42-A) | 0.009% | |

Design engineers and manufacturers in the radio, electrical and electronic fields are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot, fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

We will gladly supply samples for testing.

**D. M. STEWARD MFG. COMPANY**

Main Office & Works: Chattanooga, Tenn.
Needham, Mass. Chicago Los Angeles



**Large or Small**

**SQUARE, ROUND OR RECTANGULAR PAPER TUBES**

**FOR COIL WINDING**

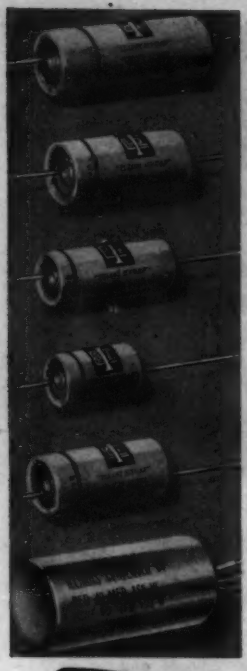
**Inside Perimeters from .592" to 19"**

With specialized experience and automatic equipment, PARAMOUNT produces a wide range of spiral wound paper tubes to meet every need . . . from ½" to 30" long, from .592" to 19" inside perimeter, including many odd sizes of square and rectangular tubes. Used by leading manufacturers. *Hi-Dielectric, Hi-Strength.* Kraft, Fish Paper, Red Rope, or any combination, wound on automatic machines. Tolerances plus or minus .002". Made to your specifications or engineered for YOU.

**Paramount PAPER TUBE CORP.**

**616 LAFAYETTE ST., FORT WAYNE 2, IND.**

*Manufacturers of Paper Tubing for the Electrical Industry*



Look to ILLINOIS for

ELECTROLYTIC CAPACITORS

of finest quality!

At Illinois' new plant the accent is, as always, on *highest quality Electrolytic Capacitors.* "Not how *many*, but how *good*" has been the fixed company policy over the years and has been directly responsible for our steady growth. A model of efficiency, our new plant features the very latest in equipment, newest production techniques and air conditioning. These factors combined with the best basic materials, closer, more rigid control and a skilled enginering staff show clearly why Illinois is better geared than ever to produce the finest in condensers.

*Your copy of our latest catalog is ready for you. Write for it today*

ILLINOIS CONDENSER CO.
1616 NORTH THROOP STREET • CHICAGO 22, ILL.

AMPERITE

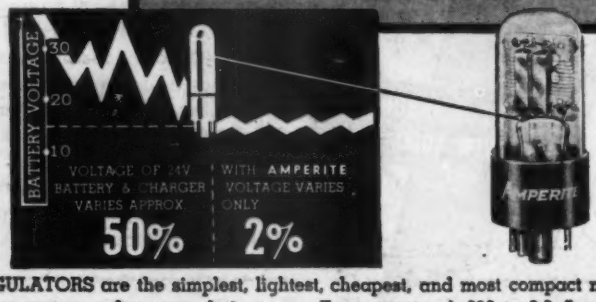
THERMOSTATIC METAL TYPE
DELAY RELAYS

PROVIDE DELAYS RANGING FROM 1 TO 120 SECONDS

FEATURES:—Compensated for ambient temperature changes from —40° to 110° F . . . Hermetically sealed; not affected by altitude, moisture or other climate changes . . . Explosion-proof . . . Octal radio base . . . Compact, light, rugged, inexpensive . . . Circuits available: SPST Normally Open; SPST Normally Closed.

PROBLEM? *Send for "Special Problem Sheet" and Bulletin.*

AMPERITE REGULATORS




Amperite REGULATORS are the simplest, lightest, cheapest, and most compact method of obtaining current or voltage regulation . . . For currents of .060 to 8.0 Amps . . . Hermetically sealed; not affected by altitude, ambient temperature, humidity.

*Write for 4-page Illustrated Bulletin.*

AMPERITE CO., 561 Broadway, New York 12, N. Y.
*In Canada: Atlas Radio Corp., Ltd., 560 King St., W. Toronto*




Corps in connection with the development and production of radio and radar equipment during World War II".

CHARLES R. DENNY was named by President Truman on Dec. 4 to be chairman of the Federal Communications Commission. He had been

C. R. Denny, new FCC head

acting chairman since Paul A. Porter left to become head of OPA.

JOHN R. GASTON is president and chief engineer of Inductive Equipment Corp., Gettysburg, Pa. He was formerly manager of the transformer division of Federal Telephone and Radio Corp.

W. R. G. BAKER, vice-president in charge of electronics department of General Electric Co., was presented with the Certificate of Appreciation by the War Department for his "outstanding contribution to the war effort by the development, design, and production of complex Signal Corps radio and radar equipment".

LOUIS GERARD PACENT, president of Pacent Engineering Corp., received the War Department's Certificate of Appreciation for "developing and adopting manufacturing techniques which involved mass production of communication equipment".

R. C. COSGROVE, general manager, Crosley Division, The Aviation Corp., received the War Department's Certificate of Appreciation for "outstanding contributions to the war effort by directing the design, development, and production of Signal Corps radio sets and radar devices".

LAURISTON S. TAYLOR, chief of the X-Ray Section, National Bureau of Standards, was awarded the Medal

# 40-500 MC GEN.

**Limited Quantity Available**

AIR CORPS TYPE TS-47/APR hi-freq Sig Gen mfgd. by Fairchild. Range 40 to 500 MC (in 2 ranges). Mfg. specs—1% accuracy at 68 F. Silver plated butterfly oscill. tank circuit. Extremely rugged. 500 cps pulse or 1000 cps sine wave AM mod. from self contained Heising mod. Output up to 3 milwatts 40 to 400 mc, up to 1 milwatt 400 to 500 mc. Self contained vert. radiator or 52 ohm co-ax. cable term. Contains power sup. designed 115-230 vac 50-2400 cps or ext. bat. RF output variable. Excellent for pre-flight check of VHF receivers and hi-freq work demanding accuracy and versatility in above freq range. Brand new and complete with tubes in carrying case. Dim. 11¼" H X 9¼" W X 6¾" D.

**YOUR COST $165.00**

• • • • • •

# FIELD MIKE

**SIG. CORPS T-21B**

- **2 Tube res-coupled Amp.**
- **Condenser Mike**
- **Remote Control Relay**
- **Rugged Construction**

FIELD ARTILLERY microphone Sig. Corps type T-21B designed to be arranged in the field in computed geometric pattern for the purpose of determining range and intensity and direction of gunfire. Internal 2 stage res. coupled amp uses 1 type "30" and 1 type "32" tubes. Contained relay controls filament circuit from remote point on applying "B" volt. Condenser mike head designed to respond at detonation freqs. **IDEAL** for use with geophysical sonde, explosion warning, well "sounding" and mine safety equip. Housed in rugged brass cylinder. Dim. 1" dia. X 16⅛" H. Diagram supplied. All units brand new (less tubes) in sealed cartons.

**YOUR COST $23.50**

**20% Remittance—Balance C. O. D.**
**All Prices FOB N.Y.C.**

## KELVIN ELECTRONICS

**74 Cortlandt St., New York 7, N. Y.**

# Life-Time Switch?

*We think so—and so do our customers. Our tests are discontinued after 30,000 on-off cycles. They're good!*

SPST ROTARY SNAP SWITCH

3A—125 V., 1A—250 V. Catalog No. 100
⅛" IPS x 5/16" Shank, Single Hole Mounting
6" Leads, One Knurled Nut

*Listed by Underwriters' Laboratories, Inc.*

**Slater** ELECTRIC & MFG. CO., Inc.
34-63 56th ST. WOODSIDE, L. I., N. Y.

**WRITE FOR BULLETIN**



# flexible SHAFTS

**FLEXIBLE SHAFTS**

that carry power around any corner have many new uses in peace-time developments. Faithful, dependable power drives or remote control in airplanes, automobiles, radio, and many other commercial products.

Shafts made to your specifications. Our engineering department will work out your particular power problem without obligation.

*Write today for Manual D*

CHICAGO

## F. W. STEWART MFG. CORP.

**4311-13 RAVENSWOOD AVE.**
**CHICAGO 13, ILL.**
WEST COAST BRANCH:
431 Venice Blvd., Los Angeles 15, Cal.



# "Alnico" permanent magnets

Specializing in the production of highest quality Alnico Magnets in all grades including new triple strength No. 5.

Production material checked to assure highest uniform quality of product.

Castings made to customer's special order on the basis of sketches or blue prints furnished.

Information and suggestions furnished on request.

## GENERAL

MANUFACTURERS OF HIGH COERCIVE MAGNETIC ALLOYS

G·M MAGNETIC CORPORATION

ALNICO

10001 ERWIN AVENUE
DETROIT 5, MICHIGAN

## CAPITOL RADIO ENGINEERING INSTITUTE

***— Where Professional Radiomen Study***

—Press Wireless Photo

**CREI Home Study Training Will Keep You Ahead of Competition — Keep Others from By-Passing You to Better Jobs— By Keeping You in Pace with the Industry**

Never was there such an opportunity as exists today in Radio Communications. Thousands of highly trained expert technicians and engineers will be required.

You can pick your FUTURE. You can enjoy a permanent, profitable and lasting career.

CREI's home study training *now* will prepare you for these important career jobs. Easy-to-read-and-understand lessons are provided and each student has the benefit of individual guidance and careful supervision from a trained instructor. This is real-honest-to-goodness practical engineering training that will prepare you for a good job in many interesting fields of Communications.

Act now! See for yourself how easily you can fit yourself into one of these secure, good paying jobs in tomorrow's Communications. Mail your coupon today.

**VETERANS! CREI IS APPROVED FOR "G. I." TRAINING!**

**CAPITOL RADIO ENGINEERING INSTITUTE**

***An Accredited Technical Institute***

Dept. E-2, 16th and Park Road N. W.
Washington 10, D. C.

**MAIL COUPON FOR COMPLETE FREE DETAILS**

***And Outline of Course***

E-2

Capitol Radio Engineering Institute
16th and Park Road N.W., Washington 10, D.C.

Gentlemen: Please send me complete details describing CREI home study courses. I am attaching a brief résumé of my experience, education and present position.

Name .....

Street .....

City ..... Zone.... State.....

☐ I am entitled to training under the G. I. Bill.

Member of National Home Study Council—National Council of Technical Schools—and Television Broadcasters Association




of Freedom for his part in developing improved methods for bombing, and the Bronze Star Medal for his work under combat conditions in Europe.

FRED L. MOHLER, chief of the Atomic Physics Section of the National Bureau of Standards, was awarded the Medal of Freedom for working out a comprehensive analysis of bombing accuracy while a member of the Ninth Bomber Command in Continental Europe.

BRUCE R. LAFFERTY has been appointed general service manager by the Hallicrafters Co. of Chicago. His 18 years of radio experience includes work with the group installing the first experimental CAA instrument landing systems for airports.

B. R. Lafferty

E. F. Hembrooke

EMIL F. HEMBROOKE, director of equipment and engineering for Muzak Corp. since 1945, has been elected a vice-president of the firm.

EUGENE MITTELMANN has resigned his position as director of electronic research and development at Illinois Tool Works to set up his own research and electronic development organization in Chicago.

WILLIAM J. HALLIGAN, president of The Hallicrafters Co., was presented with the War Department's Certificate of Appreciation for "outstanding contributions to the war effort in the engineering and production of complex radio equipment for the Armed Forces during World War II".

FRANK M. FOLSOM, executive vice-president of RCA in charge of the RCA Victor Division, received the War Department's Certificate of Appreciation for outstanding contributions to the U. S. Army Signal Corps program during the war.


*It Costs You Less To Pay a Little More For*

**SILLCOCKS-MILLER PLASTIC PARTS**

When you require plastic parts fabricated to close tolerances, you can always depend on Silcocks-Miller.

This organization pioneered in the precision fabrication of parts from plastic sheets, tubes and rods. Out of this long experience, Sillcocks-Miller engineers offer you the understanding, skill and facilities to produce plastic parts to your exact requirements or to help you work out suitable designs.

This know-how saves you time, trouble and money. That's why "it costs you *less* to pay a little more for Sillcocks-Miller quality."

***Write for Illustrated brochure***

**THE SILLCOCKS-MILLER CO.**

10 West Parker Avenue, Maplewood, N. J.
Mailing Address: South Orange, N. J.

SPECIALISTS IN HIGH QUALITY, PRECISION-MADE PLASTICS FABRICATED FOR COMMERCIAL, TECHNICAL AND INDUSTRIAL REQUIREMENTS.

EISLER

## ELECTRICAL & ELECTRONIC EQUIPMENT

## ELECTRONIC TUBE EQUIPMENT

24-HEAD RADIO TUBE EXHAUSTING MACHINE

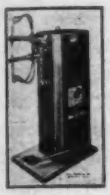
We Make Complete Equipment For The Manufacture Of Incandescent Lamps, Radio and Electronic Tubes.

## TRANSFORMERS OF ALL TYPES

For LIGHTING — FURNACES — POWER — PHASE CHANGING — DISTRIBUTION — ETC.

Air, Oil, or Water Cooled

Sizes 1/4 To 250 KVA



## SPOT WELDERS!

OF ALL TYPES
FOR ALL PURPOSES
SIZES 1/4 TO 250 KVA
Butt Welders · Gun Welders
Arc Welders
Neon Sign Units
Fluorescent Tube
Manufacturing Equipment

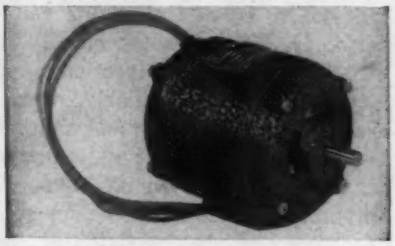
CHAS. EISLER

**EISLER ENGINEERING CO.**

751 So. 13th St. (Near Avon Ave.), Newark 3, N. J.

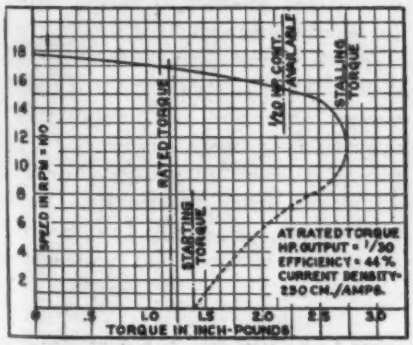
---

## NEW MODEL



**ELINCO TYPE ALP**

TYPICAL PERFORMANCE CURVE



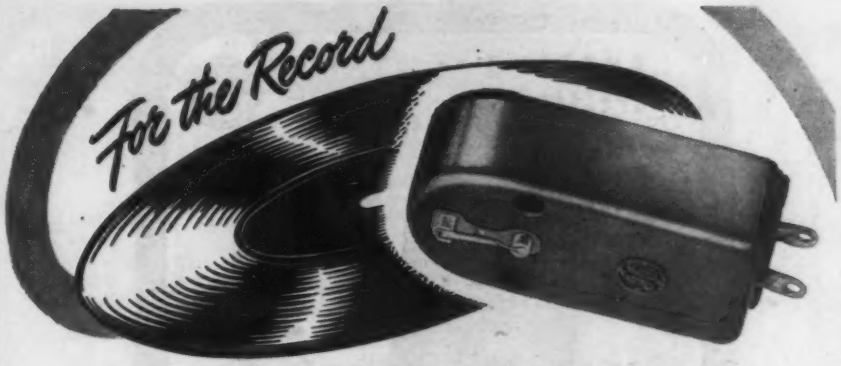

*Type ALP-191; 110 volt 60 cyc. single-phase Capacitor start & run· Motor Capacitor Value 4.25 Mfd. Curve #235.*

Elinco ALP Frame Motors are 3⅜" x 4-5/16" capacitor start and run, two and four pole AC motors, internal fan cooled. Continuous duty rating—as induction motor to 1/30 h.p. at 1700 r.p.m.; as synchronous motor to 1/60 h.p. at 1800 r.p.m. Substantially higher ratings are available at speeds of 3400 and 3600 r.p.m. respectively. Also, higher rating for intermittent duty.

*Write for Temporary Bulletin 46-A*

**ELECTRIC INDICATOR CO.**
STAMFORD, CONNECTICUT

---




# THE GENERAL ELECTRIC VARIABLE RELUCTANCE PICKUP

RECORD enthusiasts are critical customers—whether they be devotees of Bach or boogie-woogie. Better and better reproduction of their favorite recordings is an insistent demand that must be met.

The General Electric Variable Reluctance Pickup can help you to meet that demand. It will appeal immediately to the technical mind due to its simplicity and direct resolution of difficulties often associated with phonograph pickups.

Check this list of major features:

- **Low Needle Talk**
- **Negligible needle scratch**
- **Low Distortion**
- **Permanent sapphire stylus**
- **Minimum record wear**
- **Frequency response 30-10000 cycles**
- **Not affected by adverse climatic conditions**

For complete information write to:
*General Electric Company, Electronics Department, Syracuse 1, N.Y.*

# GENERAL ELECTRIC

168-P1

---

# LOGARITHMIC AC VOLTMETER —WIDE BAND AMPLIFIER—

Advanced Design gives you a sensitivity and frequency response never before obtained.

No other Voltmeter offers all these advantages

- Range .0005 to 500 volts
- Frequency 5 CPS to 2.0 MC
- Logarithmic voltage scale
- Linear DB scale
- Input 2 Megohm 15 MMF
- Accuracy ±2%
- Stability ±1% 105 to 125 V.

Ideal for Audio, Supersonics, Lower Radio Frequency Spectrum. Measures Stage Gain, RF and IF Amplifiers on Broadcast Receivers.

*Write For Complete Information*

## Instrument Electronics

**42-17A Douglaston Parkway** **Douglaston, L. I., N. Y.**

# What Makes A Mailing Click?

● *Advertising men agree —the list is more than half the story.*

*McGraw-Hill Mailing Lists, used by leading manufacturers and industrial service organizations, direct your advertising and sales promotional efforts to key purchasing power. They offer thorough horizontal and vertical coverage of major markets, including new personnel and plants. Selections may be made to fit your own special requirements.*

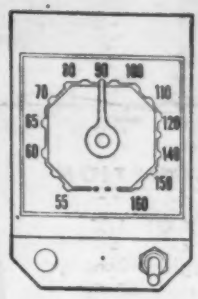
*New names are added to every McGraw-Hill list daily. List revisions are made on a twenty-four hour basis. And all names are guaranteed accurate within two per cent.*

*In view of present day difficulties in maintaining your own mailing lists, this efficient personalized service is particularly important in securing the comprehensive market coverage you need and want. Ask for more detailed information today. You'll probably be surprised at the low over-all cost and the tested effectiveness of these hand-picked selections.*

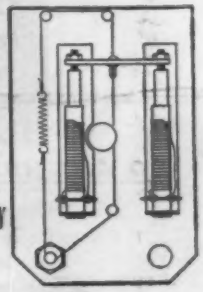
McGraw-Hill Publishing Co., Inc.
DIRECT MAIL DIVISION
330 WEST 42nd ST.
NEW YORK 18, N. Y.

# ATTENTION MANUFACTURERS and DISTRIBUTORS

## SUPERHETERODYNE PERMEABILITY TUNERS




- 535 to 1660 KC Complete
- 3 Color Dial and Drive
- All units Pre-Tracked at Factory



**We also make a Slide Rule type unit for Supers and TRF type to replace a single condenser.**

***Open facilities for Die work, Stamping, Coils, Assembling. Complete and extensive Engineering and Electrical laboratories available. Send us your inquiries for quotations.***

**AERMOTIVE EQUIPMENT CORP.**
1632 CENTRAL ST. KANSAS CITY, MO.
NEW YORK OFFICE
H. BRAVERMAN 161 WASHINGTON ST., N. Y. 6, N. Y.

*Trade Mark Reg. U. S. Pat. Off.

Quality rectifiers, made for manufacturers of quality instruments by one of the oldest manufacturers of dry disc rectifiers. Electrox Rectifiers are especially adapted to the specific needs of individual users – at no premium in cost.

Write for Cir. 446.

*Electrox Division*
**THE SCHAUER MACHINE CO.**
2119 Reading Road Cincinnati 2, Ohio

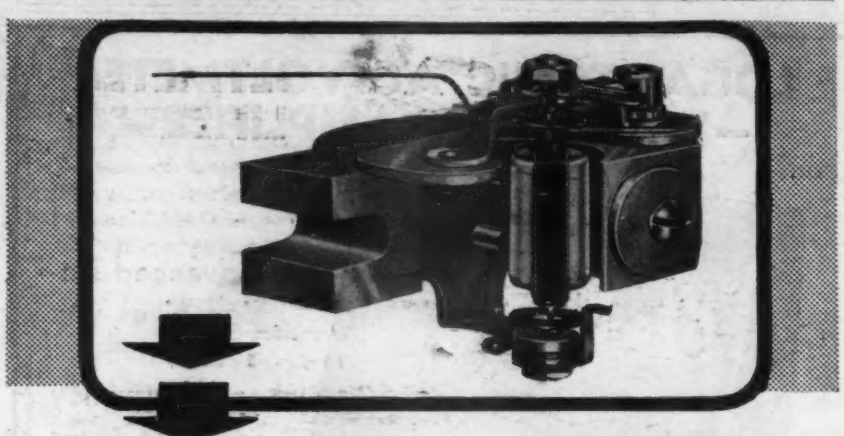
- METAL AND PLASTIC SPECIALTIES
- STAMPINGS
- SCREW MACHINE PARTS

**INSTRUMENT HOUSINGS • PANELS • CHASSIS**
*Manufactured to your Requirements*

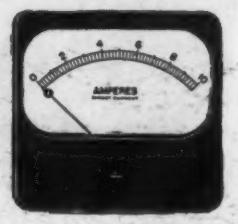
Experienced fabrication and dependable service for all types of radio and electronic parts. Send us your drawings and specifications for quotation.

**STAMFORD METAL SPECIALTY CO., 429 W. BROADWAY, N. Y. 12**
*Metal Work of Every Description*

ANOTHER SPECIAL BY PROGRESSIVE
QUALITY PROMCO BRAND
BLUE PRINT
ACTUAL SIZE
ENLARGED FOR DETAIL
CATALOG SHOWS DOZENS MORE
Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, dec. equivs. of fractions, other purchasing and engineering helps. Write for Catalog 18.
The PROGRESSIVE MFG. CO.
50 NORWOOD ST. TORRINGTON, CONN.



Burlington INSTRUMENTS




Precision Movement • Dependability Unlimited

Alnicô Magnets in all DC Instruments—Phosphor bronze control springs—perfectly aligned jewel supports—non-shifting balance weights—added to its many other superior construction features enables Burlington Instruments to maintain critical characteristics.

All ranges AC or DC available in 2½", 3½", 4½" sizes, rectangular and round.

*Inquiries invited for your specific requirements.*

BURLINGTON INSTRUMENT COMPANY 115 FOURTH ST. BURLINGTON, IOWA


# NEW BOOKS

## Principles of Radar

*By members of the staff of the Radar School of M. I. T. McGraw-Hill Book Co., Inc., 1946, Second Edition, approximately 800 pages printed by offset from manuscript, $5.00.*

THE FIRST edition of this book, the first on the subject generally available, was undertaken late in 1942 to serve as a basic text for training Army and Navy officers. The material was prepared by individual members of the teaching staff. The present edition represents a reworking of much of the earlier material, the addition of new material, and the elimination of much text describing circuits which are already obsolete.

As any officer who took the M. I. T. radar course will state, radar is not a simple subject and this is not a book which one can sit down and consume like a twenty-five cent whodoneit. In fact, it would require an exceptionally absorptive mind to master the contents of the book in six months. A recital of some of the chapter headings with their approximate dimensions will indicate what the student will learn if he takes up radar seriously. The chapter on timing circuits requires 23 sections and about 100 pages; similarly, receivers take up 30 sections and another 100 pages. Other hundred-page chapters are those on r-f lines and antennas; almost the same space is needed for triode transmitters, for modulators, wave guides and resonators and about half this amount for servos and synchros.

There is not a radar picture in this book. It is straight theory and design data and not installation, operation or maintenance. It is packed full of quantitative determinations using modern tubes and components, plus all the microquantities involved in microwave equipment.

Although the subject, radar, may seem to be vertical, the contents of this book have rather horizontal bearing on the new world of microwaves and all those techniques which employ pulses, transients, cathode-ray tubes, magnetrons and klystrons, wave guides, megacycles and megawatts, square and tri-

## LESS THAN .5% DISTORTION
**With 20 Watts at 60 Cycles**

## FREED 60 CYCLE FILTER
**Type 1050**

**FIVE INSTRUMENTS In ONE**

1 Constant Voltage Transformer
2 Variac
3 60 Cycle Low Pass Filter
4 Two Decade Attenuator—, 1% Precision
5 1% 150 Volt A.C. Voltmeter

Indispensable for calibration of instruments, where the form factor of the applied voltage is important (A.C. instruments and vacuum tube voltmeters) and for measurements of harmonic distortion of amplifiers, transformers and tubes. The instrument is entirely self contained and A.C. operated.

*Send for catalogue of Laboratory Test Equipment*

**FREED TRANSFORMER CO., INC.**
78 Spring St., New York 12, N. Y.

## FOR THE MOST EXACTING APPLICATIONS

Where dependability and economy are vital, leading manufacturers specify Westfield nuts of special design.
Send us your drawings and specifications for recommendations and prices.
WMP
WESTFIELD METAL PRODUCTS CO. Inc.
WESTFIELD, MASS.
Custom Made Nuts in Brass, Steel and Various Alloys

*Tired . . .*

of thumbing through files and folders for information on product sources and product specifications?

*Use the 1946*
## electronics BUYERS' GUIDE

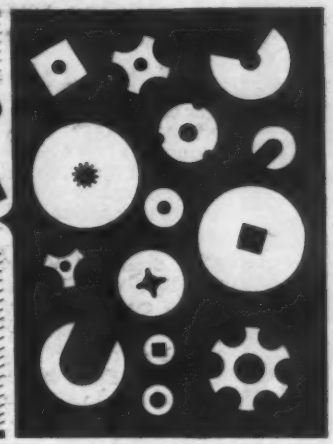
You'll find informative, catalog-type copy of leading manufacturers of electronic components, equipment, and allied products in this convenient, year 'round reference book.

*and don't forget*
**TO WATCH FOR THE 1947-48 ISSUE . . . COMING JUNE 15th**

## QUADRIGA WASHERS

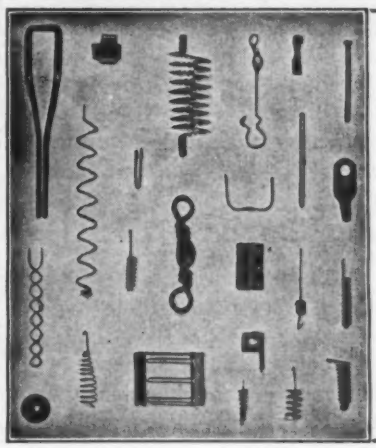
Meet requirements of the electronic field — QUADRIGA WASHERS, to your specifications. Prompt delivery of any quantity. Special flat, tension and spring, formed and drawn, cupped and finishing. Write for valuable catalog.

**DESIGNED FOR PRECISION JOBS.**



ALSO SMALL METAL STAMPINGS, ANY DESIGN

**THE QUADRIGA MFG. CO.**
221-A W. Grand Ave., Chicago 10, Ill.



## SMALL PARTS

Filaments, anodes, supports, springs, etc. for electronic tubes. Small wire and flat metal formed parts to your prints for your assemblies. Doubles pointed pins. Wire straightened and cut diameter up to ⅛-inch. Any length up to 12 feet.

LUXON fishing tackle accessories.

Inquiries will receive prompt attention.

**ART WIRE AND STAMPING CO.**
227 High St. Newark 2, N. J.

# ADVANCE Impulse Relay

**NO A.C. HUM . . . NO POWER CONSUMPTION**

***Where these two factors are important . . .*** the impulse relay finds wide application.

Essentially an electrically operated toggle-switch, the impulse relay is energized only for an instant when switching is desired. With each "impulse" of power, contacts are shifted and held by a pawl-ratchet-cam mechanism. At all other times the coil consumes no power . . . makes no hum.

For all voltages A.C. or D.C., and available in DPST and DPDT combinations with contact ratings up to 10 amps.

*Further details and free catalog on request*

Advance Relays

**ADVANCE ELECTRIC & RELAY CO.**

**1260 West 2nd St., Los Angeles, California • Phone Michigan 9331**

# DECADE SCALING UNIT

**TYPE YYZ-1**

THIS unit offers the research laboratory a quick and effective means of counting the number of pulses from any desired source. It will prove invaluable in such studies as:

- **Nuclear Research**
- **Radioactivity**
- **Mass Spectography**

In addition it will be found extremely useful:

- **For Timing Purposes**
- **For Counting Rapidly Recurring Phenomena**
- **For Use in Conjunction with Calculating Machines**

For additional information, write: *General Electric Company, Electronics Department, E-6411, Syracuse 1, N.Y.*

**GENERAL ELECTRIC**

184-P1




angular wave forms, followup systems, and many other subjects which are not even mentioned in many prewar textbooks.

The book is rather difficult to read because it is not made by letterpress, and some of the lettering on diagrams is small. The subject matter, however, which one needs to really understand the new techniques and how to use them is certainly in this book in very practical form. If the dimensions seem large, it is because the dimensions of radar and kindred subjects are large; if it seems that much time would be required to learn the "trade", there is no better time to start; and there is no doubt that *Principles of Radar* is a good place for the serious engineer to dig in.—K. H.

## German-English Science Dictionary

By LOUIS DEVRIES, *Professor of Modern Languages, Iowa State College. McGraw-Hill Book Co., Inc., New York*, 1946, *Second Edition*, 558 *pages*, $4.50.

ALTHOUGH prepared primarily for the field of entomology, physiology, physics, botany, chemistry and medicine, this handy volume will prove useful to the electronic engineer who must study German literature on applications of electronics in the above-mentioned fields. In this second edition the list of German abbreviations and corresponding English meanings has been more than doubled in length. Also included in the appendix are abbreviations of German periodicals, tables of German units of measure, and German names of the elements where they differ from the English. —J.M.

## Electronic Control Handbook

By RALPH R. BATCHER AND WILLIAM E. MOULIC. *Caldwell-Clements, Inc., New York, N. Y.*, 1946, 344 *pages*, $4.50.

A GUIDE to the design, selection, and operation of automatic process control systems employing electronic circuits. The theory of control systems is taken up first as regards antihunting, process delays,

speed of response, proportional position control, throttling range, and more complicated arrangements up to that designated as proportional plus floating plus second derivative controller.

Available types of transducers are taken up in detail, with illustrations of typical examples for such industrial applications as wire or sheet gaging and conversion of movement into capacitance. An entire chapter deals with temperature conversion elements. Other chapters deal with control amplifiers, control oscillators, counting and timing controls, passive networks such as bridge circuits, synchros and servo-systems, solenoids and relays, saturable reactors, and control motors.—J.M.

## Radio Tube Vade-Mecum

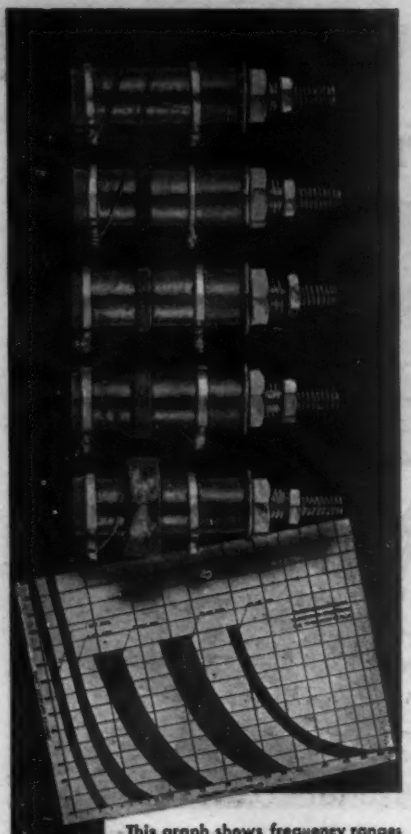
*By* P. H. BRANS. *Editions Techniques P. H. Brans, 28 rue du Prince Leopold, Anvers (Borgerhout) Belgium, 1946, 6th edition. Distributed by Editors and Engineers, Ltd., 1300 Kenwood Road, Santa Barbara, Calif., 232 pages, paper cover, $2.50.*

A NEW TABLE giving complete characteristics of German and Italian army transmitting tubes, magnetrons and accelerator tubes has been added to the latest edition of this world receiving tube manual, the 5th edition of which was reviewed in the July 1946 issue of ELECTRONICS.

The 6th edition for distribution in this country uses only English, rather than the multilingual presentation of the 5th edition, thus simplifying the task of reading through the preliminary instructive material in the front of the book. In this edition is a coupon entitling the reader to supplements free of cost, to be issued every three months until the 1947 edition appears. Because of the revision of material, the 24 additional pages represent more than the equivalent amount of added information.—A. A. McK.

---

THE TELEPHONE systems of Paris and Enghein, France have been linked by 9 and 10 cm f-m channels, with a relay station at Montmorency. Twelve calls can be handled simultaneously each way.

This graph shows frequency ranges covered by each unit. Write us for your full-size copy.

Five Standard Slug-Tuned LS3 Coils Cover ½ to 184 mc

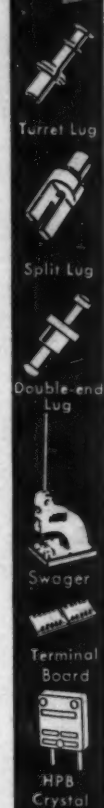
For strip amplifier work, the compact (1⅛" high when mounted) LS3 Coil is ideal. Also for Filters, Oscillators, Wave-Traps or any purpose where an adjustable inductance is desired.

Five Standard Windings—1, 5, 10, 30 and 60 megacycle coils cover inductance ranges between 750 and 0.065 microhenries.

CTC LS3 Coils are easy to assemble, one ¼" hole is all you need. Each unit is durably varnished and supplied with required mounting hardware.

SPECIAL COILS

CTC will custom-engineer and produce coils of almost any size and style of winding...to the most particular manufacturer's specifications.




Consult CTC for Three-Way Component Service

Custom Engineering . . . Standardized Designs . . . Guaranteed Materials and Workmanship

CAMBRIDGE THERMIONIC CORPORATION

437 Concord Avenue, Cambridge 38, Mass.



Announcing

*The 1st volume in the long-awaited Massachusetts Institute of Technology* RADIATION LABORATORY SERIES

*Bringing you*

the engineering data you need to design RADAR SYSTEMS

Here is an important book which presents the general principles of the design of various radar systems. From the standpoint of the designer the book discusses the basic considerations which underlie and are particular to systems design. After a general approach to problems encountered, it takes up the leading design considerations for the important components that make up a radar set. Two new and important auxiliary techniques—moving target indication and the transmission of radar displays to a remote indicator by radio means—are fully treated. Detailed examples of actual systems are included. Anyone interested in the varied applications of radar will find this new volume of immense value as a basic, useful reference.

Ready Soon

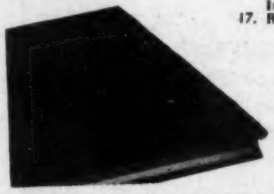
RADAR SYSTEM ENGINEERING

Edited by Louis N. Ridenour, Editor-in-Chief, Radiation Laboratory Series; Associate Professor of Physics, University of Pennsylvania. Approximately 900 pages, 6 x 9, $7.50.

This is the first of twenty-eight volumes prepared principally by members of the Radiation Laboratory maintained during the war at the Massachusetts Institute of Technology under contract with the National Defense Research Committee of the Office of Scientific Research and Development. The Laboratory was the foremost U.S. research and development institution in the field of microwave radar. The accuracy and usefulness of the material made available in these volumes is attested by their authoritative background.

Contents

1. Introduction
2. The Radar Equation
3. Properties of Radar Targets
4. Limitations of Pulse Radar
5. C-W Radar Systems
6. The Gathering and Presentation of Radar Data
7. The Employment of Radar Data
8. Radar Beacons
9. Antennas, Scanners, and Stabilization
10. The Magnetron and the Pulser
11. R-F Components
12. The Receiving System—Radar Receivers
13. The Receiving System—Indicators
14. Prime Power Supplies for Radar
15. Examples of Radar System Design
16. Moving-target Indication
17. Radar Relay



EXAMINE 10 DAYS FREE

McGraw-Hill Book Co., 330 W. 42nd St., N.Y. 18
Send me M.I.T. Radiation Laboratory Series, Vol. 1—Radar System Engineering for 10 days' examination on approval. In 10 days I will send $7.50 plus few cents postage or return book postpaid. (Postage paid on cash orders.)

Name .....
Address .....
City and State .....
Company .....
Position .....L-2-47

For Canadian price write Embassy Book Co., 12 Richmond St. E., Toronto 1

# PROFESSIONAL SERVICES

**Consulting — Patents — Design — Development — Measurements**

**in**

**Radio, Audio, Industrial Electronic Applications**

## H. RUSSELL BROWNELL

*Consulting Engineer*

Specializing in Measurements & Testing Instruments & Techniques - Electrical - Electronic - Magnetic.

188 West 4th St. New York 14, N. Y.
Chelsea 2-4208

## ELM LABORATORIES

ELECTRONIC-MECHANICAL RESEARCH & DESIGN

*Patented ELM Developments include*

PREGRAME Automatic Radio Program Tuner, Famous "Gerty" Direction Finder Loop, Sealed Xtal Holder. Home Receiver Designs.

20 South Broadway Dobbs Ferry, New York
Phone Dobbs Ferry 4058

## JOSEPH RAZEK, Ph.D.

*Consulting Physicist*

Electric and Mechanical Engineering Problems
Instruments and Control Devices Electronics
Specialists in Colormetry, Spectrophotometry and Industrial Color Control
Laboratory and Shop Facilities

202 Darby Road Llanerch, Pa.
Phone Hilltop 6910

## EDWARD J. CONTENT

*Acoustical Consultant*

and

Audio Systems Engineering, FM, Standard Broadcast and Television Studio Design.

Roxbury Road Stamford 3-7459
Stamford, Conn.

## PAUL E. GERST & CO.

CONSULTING ENGINEER

Specialists in
Electrical Product Design

El. Machinery, Apparatus & Applications
El. Appliances, Hi-Frequencies Apparatus
Electronics, Radio Communications

205 W. Wacker Dr. Chicago 6, Ill.

## ARTHUR J. SANIAL

*Consulting Engineer*

Loudspeakers and Allied Devices

168-14 32 Ave. Flushing, N. Y.

## DONALDSON ELECTRONICS LABORATORY

*Research and Development*

Shoran Radio Survey Consultant
Custom Built 'Scoopes - Trick Circuits
Microsecond Sweeps - Microwave Systems
Industrial Applications

P.O. Box 1486 San Antonio, Texas

## C. M. HATHAWAY

*Consulting Engineer*

Research and Development
Product Designs

Tool & Methods, Engineering
Pilot Manufacturing

1315 S. Clarkson St., Denver 10, Colorado

## TECHLIT CONSULTANTS, INC

Technical literature and art. Specialists in electronics. Instruction manuals, sales brochures, catalogues, isometrics, perspective, photo-retouching, schematics, wiring diagrams. Expert work at low cost. We have never missed a deadline.

140 Nassau Street New York 7, N. Y.

## STANLEY D. EILENBERGER

*Consulting Engineer*

INDUSTRIAL ELECTRONICS

Design—Development—Models
Complete Laboratory and Shop Facilities

6309-13—27th Ave.
Kenosha, Wis. Telephone 2-4213

## INDUSTRIAL DEVELOPMENT ENGINEERING ASSOCIATES

*Engineering Consultants*

Electronic Control, Motion Picture & Sound Equipment
Development—Design—Models

5874 College Ave. Indianapolis 5, Ind.

## RAYMOND M. WILMOTTE INC.

A Complete Engineering Service for the Application of Electronics to Industry

Consultation Design Construction

286 West 55 Street 1713 Kalorama Road N. W.
New York 19, N. Y. Washington, 5, D. C.

## ELECTRONEERS

*Electronic Consultants*

Industrial - Communications - Medical

Write or phone for preliminary survey without charge.

489 Fifth Ave. New York 17, N. Y.
MUrray Hill 2-2492

## RICHARD C. KLEINBERGER

*Licensed Professional Engineer*

Electronic Heating Applications

20 Cushman Road. White Plains, N. Y.

## YARDENY ENGINEERING CO.

Remote Controls (Wires and Wireless)
Automatic Devices

Electronic • Electrical • Mechanical
Consultation • Designing • Manufacturing
Licensing

105 Chambers Street New York, N. Y.
Worth 2-3584, 3535

YOUR card here builds prestige for you and helps to make your name familiar in the field. The cost is extremely small in proportion to its value as a business aid.

## ALBERT PREISMAN

*Consulting Engineer*

Television, pulse Techniques, Video Amplifiers, Phasing Networks, Industrial Applications

Affiliated with
MANAGEMENT-TRAINING ASSOCIATES

3308-14th St., N.W. Washington 10, D. C.

## PAUL D. ZOTTU

*Consulting Engineer*

INDUSTRIAL ELECTRONICS

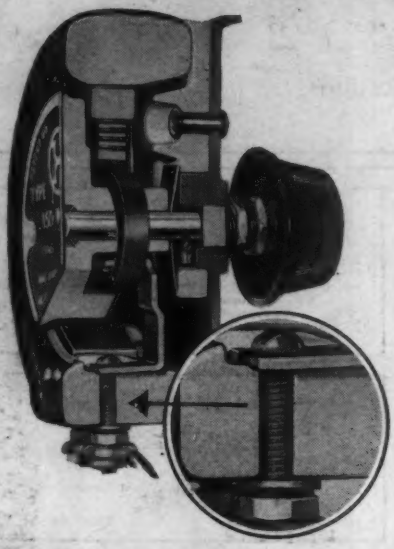
High Frequency Dielectric and Induction Heating Applications, Equipment Selection, Equipment and component Design, Development, Models.

272 Centre St. Newton, Mass.
BIG-9240

**THE REAL *VALUE***

*of placing your unusual problem in the hands of a competent consultant eliminates the elements of chance and uncertainty from the problem and provides real facts upon which to base decisions.*

# RUGGED Screw Terminals for a RUGGED Rheostat



The sturdy screw terminals are integral with the massive ceramic winding core—a *great* core that gives 25% more capacity. These solid screw studs cannot be deformed nor ripped loose.

And this is only one of several exclusive features of this line of rheostats, ranging from 50 to 500 watt capacity.

Our 10 watt and 25 watt rheostats also, and many different types of Hardwick-Hindle resistors, offer other exclusive advantages.

Write us today. Our engineers are at your service.

**HARDWICK, HINDLE, INC.**
RHEOSTATS and RESISTORS
Subsidiary of THE NATIONAL LOCK WASHER COMPANY
NEWARK 5, N. J. ESTABLISHED 1886 U. S. A.



# BAKELITE SHEETS, RODS AND TUBES

On special mill shipments we can give prompt delivery. Also complete fabrication service backed by over 20 years of experience.

**ELECTRICAL INSULATION CO., INC,**
12 Vestry St., New York 13, N. Y.


# Backtalk

**This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.**

## Loran for Aircraft

Dear Sir:

As an operational navigator of some eighteen years experience in both marine and air navigation, I am deeply concerned as to a statement made in your lead article in the September 1946 issue of ELECTRONICS.

In referring to the CAA omnidirectional beacon, which your author admits is two years away commercially, and for which only a small portion of the $300,000 the CAA has allocated for radio and radar research it is presumed will be available, your author makes the following statement: "omnidirectional ranges, *are said* to be superior to loran for use on long overwater courses, and over large land areas, such as jungles and deserts where locations of numerous ranges on the ground is impossible."

I would appreciate knowing "Who" said, the beacon was an improvement over loran, and upon what actual service or demonstration this statement was made. Consider that some $300,000,000 have been invested in loran, and that these stations are now operating on the air and are *not* two years away commercially . . .

In January, 1946, at NAS Floyd Bennett Field, New York, I put my research plane and loran navigator through . . . a flight demonstration of loran, that if anything, proved it was more practical and more accurate for air traffic control, air traffic holding patterns, and in conjunction with GCA or radar instrument let-downs than any system yet devised by the CAA.

Considering the fact that none of the present loran stations were sited for air-navigation, or air-traffic control, and that NAAS, Charlestown, Rhode Island, is not in ideal loran coverage, the New York

# CONTACTS

FOR THE FIELD OF ELECTRONICS


FINE RIBBONS
OF
TUNGSTEN and MOLYBDENUM

Quality and accuracy in our fabrication of Tungsten & Molybdenum Ribbons have characterized our service to the Electronic industry.

*A development of*

**H. CROSS Co.**
15 Beekman St., New York 7, N.Y.

Solve Wire Stripping Problems with
"SPEEDEX"
WIRE STRIPPER KIT

The famous "Speedex" Wire Stripper complete with 7 interchangeable blades for stripping any size wire from No. 8 to No. 30 will be the handiest tool in the shop. Strips 800 to 1000 wires per hour—cuts wires too. Just press the handle and the job is done. For use with solid or stranded wires.

WRITE DEPT. E FOR FULL PARTICULARS
**GENERAL CEMENT MFG. CO.**
ROCKFORD, ILLINOIS, U. S. A.

**Kahle**

**ELECTRON TUBE MACHINERY OF ALL TYPES *STANDARD AND SPECIAL DESIGN***

*We specialize in Equipment and Methods for the Manufacture of*

RADIO TUBES
CATHODE RAY TUBES
FLUORESCENT LAMPS
INCANDESCENT LAMPS
NEON TUBES
PHOTO CELLS
X-RAY TUBES
GLASS PRODUCTS

*On Production or Laboratory Basis*

**Kahle ENGINEERING CO.**
1309 SEVENTH STREET
NORTH BERGEN, N. J., U. S. A.

**WE manufacture a complete line of equipment**

SPOT WELDERS, electric from ¼ to 50 KVA
TRANSFORMERS, special and standard types
INCANDESCENT LAMP manufacturing equipment
FLUORESCENT TUBE MAKING EQUIPMENT
ELECTRONIC EQUIPMENT, vacuum pumps, etc.
WET GLASS SLICING and cutting machines for laboratory use
GENERAL GLASS working machines and burners
COLLEGE GLASS working units for students and laboratory

AC ARC WELDERS from 100 to 400 Amps

EISLER ENGINEERING CO.
731 So. 13th St. (near Avon Ave.) Newark, New Jersey

**RADIO BOOKS BY MAIL**
OVER 125 TITLES IN STOCK

SAME-DAY SHIPMENT ON 98% OF ALL MAIL ORDERS. Books of nearly all radio publishers. If you don't know price, send deposit and we'll ship C.O.D.

SEND STAMP FOR CATALOG TO **EDITORS AND ENGINEERS, Ltd.**
1303 Kenwood Road • Santa Barbara, California

**MICROMETER FREQUENCY METER**
for Checking Transmitters from 100 Kc to 175 Mc. within 0.01 per cent

**LAMPKIN LABORATORIES**
Bradenton, Fla. U. S. A.

**TELEVISION POWER UNITS**
Small, compact, designed by experts.
5,000 V. D.C.—10,000 V. D.C.
Ready to mount—4" x 5" x 5"
*For manufacturers and amateurs*
**WILLARD TELEVISION CORP.**
1639 No. California Chicago 47, Ill.

**FILMGRAPH** PAT'D
**Conference Recorders**
UNINTERRUPTED Longtime (up to 12 hours) Conference & Telephone Recordings on Safety Film Models for Dictation "TALKIES"
ECONOMICAL PERMANENT INSTANTANEOUS PLAY-BACK
MILES REPRODUCER CO., INC. 812 BROADWAY, N.Y.3

**PRINTED TAPE**
*— For "Parts" Marking —*
**TOPFLIGHT TOOL CO.**
Huber Bldg., York, Pa.

High Speed Production Of Quality I. F. Coils and Sub-Assemblies, For Discriminating Manufacturers
CIL
**Clippard** INSTRUMENT LABORATORY, INC.
7125 Bank Street, Cincinnati 14, Ohio

**TELEVISION POWER COILS**
Built for high voltages
5,000—10,000—30,000 V. D. C. working
FOR MANUFACTURERS and AMATEURS
**MONROE COIL CO.**
1606 No. California Ave. Chicago 47, Illinois

REX RHEOSTAT COMPANY, BALDWIN, L. I., N. Y.
PROTECTED & UNPROTECTED
**RHEOSTATS**
WITH LUBRICATED CONTACTS
**ROTARY DRIVE RHEOSTATS**
WITHOUT BACK LASH
PROTECTED & UNPROTECTED
**ADJUSTABLE RESISTORS**
UP TO 1000 WATT
PROMPT SHIPMENTS

¶ INDUSTRY COMES TO SUN RADIO FOR ELECTRONIC EQUIPMENT

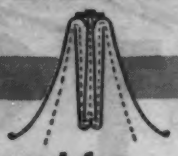
**SUN RADIO**
& ELECTRONICS CO., Inc.
ESTABLISHED 1922
122-124 DUANE ST. NEW YORK 7, N. Y. BArclay 7-1840

*This*
CONTACTS
*Section*

supplements other advertising in this issue with these additional announcements of products essential to efficient and economical production and maintenance. Make a habit of checking this page, each issue.

Classified Advertising Division
ELECTRONICS

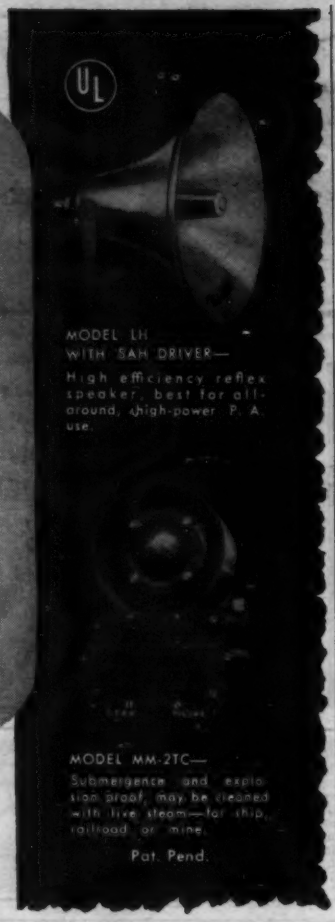
UNIVERSITY REFLEX CONSTRUCTION



Engineered for efficiency and quality

University Speakers

The conversion efficiency of UNIVERSITY loudspeakers over the useful speech frequency range is 35 to 50 percent! Parallel to this superior sensitivity, is naturalness of tone and a ruggedness which permits every model to be unconditionally guaranteed for one year. Magnets of higher magnetomotive force, greater rigidity and concentricity of voice coils resulting in smaller air-gap clearances, better heat dissipation in the voice coil, diaphragms with a higher fatigue characteristic, and exclusive "rim centering" construction are a tribute to UNIVERSITY design.



MODEL LH WITH SAH DRIVER— High efficiency reflex speaker, best for all-around, high-power P. A. use.

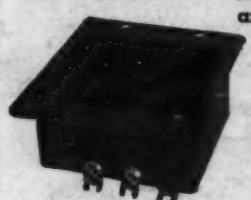
MODEL MM-2TC— Submergence and explosion proof, may be cleaned with live steam—for ship, railroad or mine.

Pat. Pend.

UNIVERSITY LOUDSPEAKERS • INC
225 VARICK STREET
NEW YORK 14, N.Y.

JONES 500 SERIES PLUGS and SOCKETS
(Heavy Duty)

P-506-CE



S-506-DB

Designed for 5000 Volts and 25 amperes per contact. Socket Contacts of phosphor bronze, knife-switch type, silver plated. Plug Contacts are of hard brass, silver plated. Made in 2, 4, 6, 8, 10 and 12 Contacts. All Plugs and Sockets are Polarized. Long leakage path from Terminal to Terminal and Terminal to ground. Caps and Brackets are of steel, parkerized. Plug and Socket blocks interchangeable in Caps and Brackets. This series is designed for heavy duty electrical work and will withstand severest type of service.

Write for Bulletin No. 500 describing this line of Heavy Duty Plugs and Sockets.

HOWARD B. JONES DIVISION
CINCH MFG. CORP.
2460 W. GEORGE ST. CHICAGO 18

Find Out Now About
★ STAR ★
CERAMICS

There are many kinds for special uses, such as applications calling for resistance to electricity, heat, moisture, chemicals or weathering agents. There are more than a score of formulas in actual production at one time in our factory.

*Send for "A Brief Survey of Technical Characteristics of molded Ceramic Products." It is right to the point.*

★

The STAR PORCELAIN CO.
Electronics Dept.
Trenton 9, N. J.



demonstration of loran was remarkable.

When one considers that radio ranges of any kind, assuming vhf range of seventy miles, will necessitate the 700-knot navigator to tune in ten or more per hour, and perform a flight pattern across the radio range jungle, trans-continental, that looks like a spider's web. Double the speed into supersonic range, and I am sure your radio ranges, omnidirectional or otherwise, can only be tagged "horse and buggy aids". Perhaps they may have some use when the CAA attempts to slow the airplane of the future down at its terminal for a landing aid.

W. J. CATLETT, JR.,
*Commander, U. S. Navy*
*Technical Development Committee for Air*
*Newport, Rhode Island*

Editors Note: The opinion expressed in the article does not represent the considered opinion of Electronics editors but is a statement of opinion held in some Government circles. The Editors, in fact, heartily agree with Commander Catlett. He expresses his opinions as an individual and they do not reflect the policy or opinion of either the Navy Department or the Institute of Navigation.

## UHF Tank Circuit

Dear Editor:

UPON READING carefully my paper "Composite Tank Circuit for Uhf" which appeared in ELECTRONICS for September 1946, I find a number of errors. The first sentence under the subheading *Operating Principle* should read, "The internal impedance of the tube was found, by experimentation, to be capacitive (instead of inductive) at lower frequencies, but to become capacitive (not inductive) as the upper frequency limit of the tube's oscillating range was approached."

The first sentence of the following paragraph should conclude, ". . . the necessary inductive reactance." The next to last sentence in the same paragraph should read in part, ". . . input to the grid-plate is inductive, the line must present a capacitance . . .".

In Table I, the first wavelength given for the tube type 1628 should be 49 cm rather than 59. In Eq. 4, a numeral one was omitted before the plus sign in the denominator. In the following paragraph the sentence beginning, "If $C' = 0, \ldots$" should read, ". . . which was before less than . . .".

P. L. BARGELLINI
*Florence, Italy*

MARCH · 1947
electronics
McGRAW-HILL

# electronics

A McGRAW-HILL PUBLICATION

## MARCH • 1947



**FLYING SKYWIRES** ..... Cover
Douglas DC3 aircraft for executives, showing just a few of its many antennas for communication and navigation

**FCC VIEWS TELEVISION ADVANCES** ..... 80
Color vs black-and-white contest sharpens as industry demonstrates competing equipment

**HEATING WITH MICROWAVES, by J. Marcum and T. P. Kinn** ..... 82
Methods of utilizing waveguides for applying energy to moving or stationary materials

**UHF TELEVISION RELAY SYSTEM, by Wilson Boothroyd** ..... 86
F-M equipment operating on 1,350 mc is useful for inter city multiple relay work or studio-transmitter link

**PRODUCTION TESTING OF TACHOMETERS, by Herbert F. Storm** ..... 92
Power for the calibration of instruments at 21 test speeds is generated electronically

**RADIO DISPATCHING FOR TAXICABS** ..... 97
Rates are reduced, income is increased and equipment costs are amortized rapidly

**TELEMETERING FROM V-2 ROCKETS, by V. L. Heeren, C. H. Hoeppner, J. R. Kauke, S. Lichtman, P. R. Shifflett** ..... 100
Time-modulated pulse system in nose of rocket telemeters 23 readings to ground over 1,000-mc radio link

**SUBMINIATURE ELECTROMETER TUBE, by C. D. Gould** ..... 106
Tetrode having very high input resistance is used in portable x-ray radiometer

**TIMER FOR DIECASTING MACHINE, by Gerald DeLong** ..... 110
Cooling of metal in 25 molding machines is controlled by simple electronic circuit

**EXPERIMENTAL C-R TUBES FOR TELEVISION** ..... 112
Greater screen brightness, all-electronic color tube, and optical relaying developments

**ULTRASONIC GARAGE-DOOR OPENER, by Boley A. Andrews** ..... 116
Inaudible vacuum-type whistle on car actuates crystal microphone feeding amplifier and relay in motor circuit

**F-M CYCLOTRON** ..... 119
World's largest cyclotron accelerates electrons to nearly the speed of light

**PREDETERMINED COUNTERS, by John J. Wild** ..... 120
Switches insert predetermined starting count as required for industrial counting, batching, timing, and totalizing

**PULSE-MODULATED OSCILLATOR, by Allan Easton** ..... 124
Circuit for generating sweep-calibrating and marking signals of uniform amplitude

**STABLE VOLTMETER, by R. W. Gilbert** ..... 130
By means of a compound feedback circuit, stability is obtained in a conductively coupled instrument

**WAVELENGTHS OF SOUND (Reference Sheet), by Bertha M. Henvis** ..... 134
Tables and simple nomograph give wavelength in common mediums at any sonic or ultrasonic frequency

BUSINESS BRIEFS ..... 74
CROSSTALK ..... 79
TUBES AT WORK ..... 138
INDUSTRIAL CONTROL ..... 142
ELECTRON ART ..... 144
NEW PRODUCTS ..... 148
NEWS OF THE INDUSTRY ..... 154
NEW BOOKS ..... 279
BACKTALK ..... 282
INDEX TO ADVERTISERS ..... 291



**DONALD G. FINK**, *Editor;* **KEITH HENNEY**, *Consulting Editor;* W. W. MacDonald, *Managing Editor;* John Markus, Vin Zeluff, *Associate Editors;* Frank Rockett, A. A. McKenzie, *Assistant Editors;* Gladys T. Montgomery, *Washington Editor;* William P. O'Brien, *Make-up Editor;* Jeanne E. Grolimund, *Editorial Assistant;* Harry Phillips, *Art Director;* Eleanore Luke, *Art Assistant*

**H. W. MATEER**, *Publisher;* **WALLACE B. BLOOD**, *Manager;* J. E. Blackburn, Jr., *Director of Circulation;* Dexter Keezer, *Director, Economics Department;* John Chapman, *World News Director;* D. H. Miller, H. R. Denmead, Jr., *New York;* Ralph H. Flynn, *New England;* F. P. Coyle, R. E. Miller, *Philadelphia;* C. D. Wardner, *Chicago;* E. J. Smith, *Cleveland;* J. W. Otterson, *San Francisco;* Roy N. Phelan, *Los Angeles;* Ralph C. Maultsby, *Atlanta;* Paul West, *London, England*

Contents Copyright, 1947, by McGraw-Hill Publishing Company, Inc. All Rights Reserved. McGRAW-HILL PUBLISHING COMPANY INCORPORATED, JAMES H. McGRAW, Founder and Honorary Chairman • PUBLICATION OFFICE 99-129 North Broadway, Albany 1, N. Y., U. S. A. EDITORIAL AND EXECUTIVE OFFICES 330 West 42nd St., New York 18, N. Y., U. S. A.—Member A. B. P., Member A. B. C.

James H. McGraw, Jr., President; Curtis W. McGraw, Senior Vice-President and Treasurer; Nelson Bond, Director of Advertising; Eugene Duffield, Editorial Assistant to the President; Joseph A. Gerardi, Secretary; and J. E. Blackburn, Jr., Vice-President for circulation operations.



ELECTRONICS, March, 1947, Vol. 20; No. 3. Published monthly, with an additional issue in June, price 75c a copy. Directory Issue $1.00. Allow at least ten days for change of address. All communications about subscriptions should be addressed to the Director of Circulation.
Subscription rates—United States and possessions, $6.00 a year, $9.00 for two years, $12.00 for three years. Canada (Canadian funds accepted) $7.00 a year, $11.00 for two years, $14.00 for three years. Pan American countries $10.00 for one year, $16.00 for two years, $20.00 for three years. All other countries $15.00 for one year, $30.00 for three years. Please indicate position and company connection on all subscription orders. Entered as Second Class matter August 29, 1936, at Post Office, Albany, New York, under the Act of March 3, 1879. BRANCH OFFICES: 520 North Michigan Avenue, Chicago 11, Ill.; 68 Post Street, San Francisco 4; Aldwych House, Aldwych, London, W.C. 2; Washington, D. C. 4; Philadelphia 3; Cleveland 15; Detroit 26; St. Louis 8; Boston 16; Atlanta 3, Ga.; 621 So. Hope St., Los Angeles 14; 738-9 Oliver Building, Pittsburgh 22.